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ABSTRACT

This curriculum guide contains 41 interdisciplinary energy and environmental education activities to help students become familiar with past, present, and alternative sources of energy as well as the economic and environmental cost of energy consumption, and to develop an awareness of how limited resources affect life style. Each activity, designed to meet one of five objectives, includes: (1) statement of topic or concept fostered; (2) list of materials needed; (3) teacher information; (4) procedure(s); and (5) evaluation methods. Materials to accompany selected activities, list of goals and objectives for energy education in San Diego County, and energy fact sheets are provided in appendices. (JN)

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an ENERGY ENVIRONMENT EDUCATION

Program for Grade 4

Superintendent of Schools, Department of Education, San Diego County

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ENERGY/ENVIRONMENT EDUCATION

GRADE 4

Prepared by

Esther Cannon	Jimmie Martinez
Shirley Folger	John Sullivan
Jerry Hooper	Kay Weil

1977

Revised by

Kay S. Weil

Contributing Writers

Richard Dryer	Jimmie Martinez
Robert M. Jones	Craig Wollitz
Michele Law	

1978

Advisory Committee

Molly Jean Featheringill, San Diego Ecology Centre
Douglas Fouquet, General Atomic Company
Clifford Fredrickson, Specialist, Science, San Diego City Schools
John Gessel, Director, School-Community Services, San Diego County Department of Education
Roy Harris, Specialist, Social Studies, San Diego City Schools
Archie Kelley, Energy Research and Development Administration
Edward Kimura, Sierra Club
Jerry Lamb, Principal, Balboa Park Project
Barbara Laczko, San Diego Gas & Electric Company
William Pettis, University of California, San Diego
Ernest Roberson, San Diego Gas & Electric Company

San Diego, California
1978
Unedited

PREFACE

Nature never gives anything away.
Everything is sold at a price.
It is only in the ideals of abstraction
that choice comes without consequence.

--Ralph Waldo Emerson

In 1976 America celebrated its 200th birthday. For about 195 of these 200 years Americans were coaxed, implored, and cajoled to consume, consume, consume. Even the hearty pioneer viewed the forests and prairies as something to be conquered and used and, when they wore out, to move on. In later years the massive efforts of Madison Avenue were to convince Americans that they should buy "more" and "bigger" everything. By the 1950's and 60's the automobile had become a symbol of wealth and prestige and the value of an automobile was measured by its horsepower, its power equipment, and the amount of chrome it carried. Americans were led to believe "there was no tomorrow" or that tomorrow would be even more rosy than today.

Occasionally in our history we had small warning signs, such as the dust bowl of the 1930's, but generally the cries of the conservationist and the ecologist were brushed off as being those of doomsday sayers and of the radical fringe. It is no wonder then that Americans were genuinely surprised and shocked when they had to stand in gasoline lines in 1973. Other warning signs quickly followed in the form of blackouts and brownouts in major American cities. In the winter of 1976-77 most of the East Coast of the United States suffered from severe shortages of natural gas and other heating fuel. By the bicentennial year gasoline rationing was a topic for serious consideration.

And so, as the nation enters its third century, Americans' views on energy and the environment are slowly beginning to change, often against their will. But the task of re-educating the American people to a more sensible and rational perspective on energy and environment has only just begun. Adults, trained for most of their lives to believe that there is an endless supply of energy and natural resources, continue to question the need for conservation. Their attitudes are epitomized by a recent newspaper article from drought-stricken Marin County which told of a young man washing down his driveway with water which should have been put to much better use. When confronted, he replied, "I can afford it, can't I?" and the newspaper caption read, "Yes, but can we afford you?" Deeply engraved attitudes of indulgence and waste are still being passed on to children. We still live in the disposable, throw-away, bigger and faster age. Energy and environmental constraints indicate that this life-style can no longer continue.

America's schools are often called on to bring about change of attitude in American society. Undoubtedly, then, it would be the schools that play the leading role in helping the new generations to develop healthier and more

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rational views of energy and the environment. It was with this in mind that this curriculum project was undertaken. It is the sincere hope of all who worked on it that the ideas and activities contained in this project will be an initial step in helping the children of our schools develop thought patterns and actions which will result in a more thoughtful use of energy and the environment.

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ORIGINS OF THIS PROJECT

For the past three years, a committee consisting of representatives from San Diego City Schools, San Diego County Schools, and a variety of community groups has been meeting to discuss energy education plans for San Diego County. This group is known as the San Diego City/County Energy Education Committee. In the fall of 1976, a subcommittee met and formulated a proposal for a funding grant from the State of California Environmental Education Grant Fund (state individualized license plate money). The grant was awarded and in the spring of 1977 a review of all available materials related to energy education was undertaken.

In the summer of 1977, a major curriculum writing project was undertaken which resulted in the production of primary grade and upper elementary grade curciculum guides containing activities and materials for teaching energy and environmental education in the classroom. This writing was undertaken by the elementary resource staff members of social studies and science from San Diego City Schools assisted by eight elementary classroom teachers. The result is a publication which contains practical classroom activities arranged in a thoughtful sequence. The writing team consisted of persons with expertise in social studies, science, and art and given a multidiscipline prespective to energy/environmental education.

During the summer of 1978, a major rewriting of the energy/environment guides was undertaken. As a result, separate guides for science and social studies were developed. The science guides provide the input data base about which the social studies lessons are written.

The continuing need for energy/environmental education is apparent since the factors related to our energy/environmental status is constantly changing. Energy/environmental education can not be static. It must continue to change to better assist students in making wise decisions as they become the energy consumers of the future.

GOALS AND OBJECTIVES

In the fall of 1976, a subcommittee of the San Diego City/County Energy Education Committee formulated a set of goals and objectives for energy education, kindergarten through 12th grade (see Appendix B). It was planned that these goals and objectives would guide curriculum development efforts at all of these grades. The intent was that energy/environmental information and concepts could be presented in primary grades and then built upon in more complex and sophisticated ways in upper elementary grades and at the secondary level. It was found that not all of the goals and objectives were applicable to primary grades. Thus, goals and objectives which guided the grade 4 writing project are listed below.

Goal: Students will become familiar with past, present, and alternative sources and forms of energy, the economic and environmental cost of energy consumption and will develop an awareness of how limited resources affect life-style.

Objective 1: Students will be able to define energy, work, force, fuel and combustion.

Objective 2: Students will be able to give examples of renewable and nonrenewable energy sources, energy forms, and energy conversions and losses.

Objective 3: Students will be able to explain energy epochs.

Objective 4: Students will be able to identify several environmental concepts that are energy-related.

Objective 5: Students will be able to give examples of activities that involve an energy cost as well as an economic cost.

ACTIVITIES

OBJECTIVE 1: *Students will be able to define energy, work, force, fuel, and combustion.*

ACTIVITY 1

Learning: A force is a push or pull in any direction exerted on some object.

Materials: Archery bow (toy will do), classroom earphones, compression type curtain rod, two nails, board, balloons, sprouted avocado seed, pinwheel, kettle and hotplate

Teacher Information: People exert forces by pushing, pulling, twisting, prying, lifting, stretching or compressing objects. Forces are exerted in nature by wind, flowing or falling water and by growing things, such as a root that cracks a sidewalk. Planetary systems are held together by forces, as are the atoms in matter. The internal parts of atoms are held together by forces. A force, while it must always act on an object, may or may not move the object. If an object does move, that motion must have been caused by a force. A change in the rate or direction of an object's motion also requires a force.

Procedure:

1. Briefly discuss, using simple demonstrations, the kinds of forces people exert, emphasizing that (a) some forces do not succeed in moving anything, and (b) if something has moved or is moving, it is certain that a force was or is being exerted. Be sure that everyone understands that not all forces are exerted by people and animals.

2. Display and demonstrate some or all of the following objects and invite the class to identify the force exerted (characterize it as a push, pull, etc., or show in which direction it is exerted) and, if possible, to decide how or where the force originates.

    a. Forces which don't move anything

        Archery bow--bow's elastic restoring force keeps string tight

        Earphones--headband's elastic restoring force grips wearer's head

        Curtain rod--install in window frame, bookcase, etc. to show force holding it in place

        Rubber band--stretched between nails on board

        Spring clothes pin

    All of these objects, as displayed, are exerting a force which does not move anything.

b. Forces which have already moved something

Archery bow--a force was applied to bend the bow to put on the string. Same applies to the curtain rod, which was compressed by a force when it was installed, and to the rubber band, which was stretched by a force.

Inflated balloon--the force which stretched the skin of the balloon was air pressure, which in turn came from chest muscle force.

Sprouted avocado seed--living cellular structures draw water into themselves while growing. As they "inflate," they can exert a large force.

c. Forces which are now moving something

Doorknob--hand exerts a twisting force, moving the knob.

Pinwheel--wind (or breath) exerts a force, moving the pinwheel.

Falling object--gravity exerts a force, making the object fall. Remind the class that in space, out of reach of gravity, objects do not fall.

Archery bow--when drawn and released, the bow exerts a force to straighten the string and keep it tight.

Kettle on hotplate--heated water turns to steam which rushes out spout, exerting wind-like force which will operate the pinwheel.*

Evaluation: Involve everyone in the discussion. Listen for misconceptions and reteach as required.

Safety Note: *This is a very worthwhile demonstration which ties in with later activities. Note that when steam is used, precautions must be taken to keep students' hands and faces out of the steam. The invisible steam, as it emerges from the kettle, can cause severe burns. The visible water droplets are less harmful. An aluminum pie pan can be used to build the pinwheel.

ACTIVITY 2

Learning: Work is what is done when a force moves an object over a distance.

Materials: Balloon, kettle and hotplate, pencil sharpener, compression curtain rod, spring clothes pin, container of water covered with plastic wrap, small table lamp, pinwheel

Teacher Information: Scientists define work in a very restricted way. Work is performed on an object only when a force succeeds in moving it. For example, a person may spend hours attempting to move a large rock; if the rock does not move, no work had been done *on the rock*. There is some work being done, however. When we move around, parts of our bodies do work on other parts of our bodies.

The motion which takes place when work is performed need not be from place to place. For example, turning a wheel about its axis requires work.

In addition to some general examples of work and some exertions of force without work, this activity includes two work processes which are vital to life on earth. These are evaporation and convection. They are vital because they are two of the major ways the sun's energy is captured for use on earth.

The sun, by evaporation, does work on the waters of the earth, lifting them to form the clouds whose rains drive our hydroelectric plants and water our crops. It is difficult to find the force in this process, but it is there. A simplified explanation is that the same force which propels steam from a teakettle acts, though more weakly, at temperatures below boiling.

A second vital process is convection, by which the sun's heat does work on the air. The resulting winds distribute clouds and other moisture over the earth's surface, and can do work for us by driving windmills. Convection occurs because warm air is lighter than cold air; it floats upward in the atmosphere when cooler air pushes in to replace it and equalize the pressure. The force here is gravity. The heavier cool air is pulled to earth, pushing the lighter warm air out of the way, as the heavier side of a balance scale lifts the lighter. Note that the common expression, "heat rises," is incorrect. It is hot air or hot water (among other things) which rise--not heat itself.

Procedure:

1. Discuss the definition of work given above. Perform some or all of the following demonstrations, and ask the students to identify, in each case, (1) the force being exerted and (2) the motion which results.

(a) Work being done USE CAUTION WITH FLAME AND STEAM.

Inflate a balloon--force of air pressure is moving skin of balloon.

Boil a kettle of water, place pinwheel in path of steam--force of escaping steam causes rotating motion of pinwheel.

Crank a pencil sharpener--muscle force imparts rotary motion to crank.

(b) No work being done

Push or pull on an immovable object, such as wall--force but no motion.

Install compression curtain rod. Ask whether rod holding itself up is doing work. Again, a force is being exerted without motion.

Display a clothes pin holding a bundle of paper--same as curtain rod example.

2. Reinforce the definition of work. Remind class that in Activity 1 it was said that if motion occurs a force must be or must have have been exerted.

(a) Evaporation

Display a container of water with plastic wrap stretched across its top, which has earlier been placed in the sun. Point out the drops of water clinging to the underside of the plastic wrap. Ask where the drops came from. Try to elicit answers which recognize that the water was lifted from the container, and point out that if this is so motion of the water must have taken place. Remind the class that the container has been in the sun, and explain that the sun does work on water all the time, lifting it into the sky to form clouds.

(b) Convection

Turn on a table lamp having a bare bulb. After a few moments to allow it to heat, hold the pinwheel horizontally over the bulb. Ask the class what is causing the pinwheel to rotate. Guide the discussion as necessary toward the realization that the force of moving air must be moving the pinwheel. Explain that as the air is warmed by the bulb it becomes lighter than the surrounding air, which in turn rushes in pushing the warmer air out of the way and equalizing the pressure.

The upward moving air then does work on the pinwheel. Explain that the sun, as it beats down in the tropics, heats so much air that it is a major cause of wind on earth.

Evaluation: Class discussion should indicate that everyone understands the definition of work. Ask each student to write down such a definition. An acceptable answer must include both force and motion.

ACTIVITY 3

Learning: Energy is the capacity for doing work. It is consumed when work is done. People have ways of storing energy.

Materials: Rubber band powered airplane, balloon, pinwheel, cuckoo clock, wind-up toy.

Teacher Information: To clarify the relationship between energy and work, consider the following analogy. Work, which is a process, may be compared to the process of spending. Energy is analogous to what is spent: wealth. Energy, like wealth, may be continuously replenished, as in the case of a salary, or may come from a relatively limited source, such as a savings account. In either case, spending tends to use up the wealth. The difference lies in whether or not it is replenished, and at what rate.

This activity begins by simply defining energy, then illustrates its consumption and some of the short-term energy storage methods people have learned to use. The next activity will cover long-term storage and begin examining the primary source of energy on earth--the sun. The concept of energy storage is presented along with the definition of energy because (1) it makes possible some interesting and instructive demonstrations, (2) it lays the groundwork for the concepts of potential and kinetic energy, and (3) it underscores the fact that energy is depletable and, in some cases, replenishable.

Because energy is not always available when or where we want it, people have discovered ways of storing it. Scientists refer to stored energy as potential energy. Of the many ways nature has given us to store energy, two are particularly convenient. These are elasticity and gravity.

Elasticity is that property of a material which causes it to resume its former shape after it is deformed. The most commonly understood example of elasticity is a rubber band which, after being stretched and released, resumes the length it had before stretching. There is more to elasticity than stretching, however. Materials exhibit elasticity when compressed. Squeeze a rubber eraser with pliers. When released, it resumes its former shape. Another elastic mode is torsion, or twisting. Twist a rubber eraser and, again, it will resume its former shape when released. Still another is bending. Bend the eraser, and it straightens when released. Note that elasticity is not limited to rubber. Steel, for example, is very elastic in the bending and twisting modes. A familiar example of steel's bending elasticity is the kitchen spatula. Torsion is less common. Some automobile trunk lids are made easier to lift by a steel rod which twists when the trunk is closed. Wood is very elastic in the bending mode, making it useful for diving boards and bows.

Not much need be said about gravity. We all know that what goes up, unless we prevent it, will surely come down.

What elasticity and gravity have in common, and the reason they are both mentioned here, is this: We do work on an object when we deform it or when we lift it. When the deformed object resumes its shape or the lifted object falls, the object can exert a force, and can move something through a distance, giving us back some of the work we put into the object. In short, elasticity and gravity *store energy*. Having means to store energy enables people to save energy for another time, or to carry it to another place, than when and where it is available to them.

Procedure: Present and discuss the definition of energy given above. Be sure to emphasize the fact that energy may be depleted and may be replenished. The money analogy given earlier may be helpful, although, if the term "money" is used, some students may have trouble seeing money as the "capacity to spend."

Display a rubber band powered airplane. Wind it, saying "Now I am doing work on the propeller by applying a force and moving the end of it through a distance." Release the airplane, allowing it to fly. Ask for comments from the class on what they saw. Try to lead them through a logical progression of observations and reasoning, such as: (1) "The plane flew. We learned earlier that where there is motion, there must have been a force." If they are interested in discussing the force at this point, they may, but it is unnecessary to what follows. (2) "If there is a force and the plane moved through a distance, work must have been done. But since no one touched the plane while it was flying, where did the energy come from to do the work?" Keep the discussion going until they understand that energy was stored in the rubber band, and that it gave back the work the teacher did on it earlier.

Display a balloon. Inflate the balloon and ask the class whether they can identify the work which took place. Lead the discussion toward a recognition that work was done on the elastic skin of the balloon. Hold the balloon near the pinwheel, and release the air. Invite class discussion about what they saw. Be sure that they realize that (1) work was done on the pinwheel by the balloon and (2) the energy from the balloon came from the work that was done on it during inflation.

Display a cuckoo clock, hanging it on some convenient place so that its weights will be free to move. Ask the class where the energy comes from to operate a clock like this one. Allow a full discussion before demonstrating the answer. Pull up the weights saying, "I am doing work on these weights by lifting them higher. We know that anything we lift up tries to come down. Will these weights fall when I let them go?" During the class' discussion, release the weights and start the pendulum. Ask again where the energy for this clock comes from. Point out that while the clock is running the weights *are* falling, though too slowly to see easily. Hang a piece of paper behind the clock and draw a line on it even with the top of the weights. After half an hour, draw another line to emphasize that one of the weights has fallen. Discuss the origin of the energy. Be sure the class understands that the energy which runs the clock came from the work done earlier on the weights.

Return to the plane. Wind it a few turns, then release the propeller. When the propeller stops, ask why it stopped. If necessary, prompt the class by asking what happened to the energy. Grasp the weights on the cuckoo clock, slackening the chains slightly so the clock stops. Encourage full discussion of depletion of energy. Ask whether, now that the energy is gone, it is possible to obtain some more. Be sure that the class understands that the energy can be easily replaced.

Demonstrate the wind-up toy. Choose a toy in which the steel spring is clearly visible as it winds and unwinds. Call attention to the spring as it is being wound. Complete the winding and allow the toy to operate. Throughout the process, reinforce the points made earlier: work is done on the spring (by bending it); the spring gives back the work done on it, making the toy operate; the energy runs out, causing the toy to stop; the energy can be replenished by winding up the toy again.

Evaluation: During each of the discussions above, attempt to identify those students who have missed a concept. Steer the discussion toward a review of the concepts missed. Reteach as needed.

ACTIVITY 4

Learning: Work is force applied over a distance. Work is a force that succeeds in moving something. When we move parts of our body, we are doing work.

Materials: List these activities on the chalkboard or on sentence strips in a pocket chart: chin-ups, push-ups, climbing stairs or a ladder, swimming, traveling across monkey bars.

Procedure: Tell the class that some of the activities we call play are considered work by scientists, because science defines work as a *force* that succeeds in *moving* something. Pantomime or perform each of the activities listed. For each ask: "What is the motion? What is the force?" A recorder should write down what the group identifies as the force and the motion. (Possible answers are supplied in parentheses.)

Activity	Force	Motion
chin-ups	(pull on bar)	(body rises)
push-ups	(push on floor or ground)	(body is lifted)
climbing stairs or a ladder	(push by feet on rungs or stairs)	(body is moved up)
swimming	(push of kicking legs on water or pull of arms)	(body moves through the water)
traveling across monkey bars	(pull of arms on bars)	(body moves to other side of monkey bars)

Evaluation: Ask individuals to restate why these activities are called work. Both force and motion should be included.

ACTIVITY 5

Learning: Demonstration of storage and recovery of energy by doing work against elasticity; introduction to potential are kinetic energy.

Materials: Rubber bands; empty wooden thread spool; one long and one short wooden match stick or two pieces of plastic straw; ¼" thick wax washer cut from a piece of candle and a small nail. Ruler (metric/English).

Teacher Information: Energy input and output to a system may be shown using this miniature power plant. Point out that without energy input, after building the power plant, it will remain still. If energy is put into the system, by winding the rubber band or by pushing it, the racer may be made to move. (Note: The rubber band when twisted has *potential* energy stored in the elasticity of the rubber band; the moving spool is exhibiting *kinetic* energy.)

Procedure: Directions for constructing the power plant are as follows:

Step 1: Drive the nail into the spool, about 1/8" from the hole.

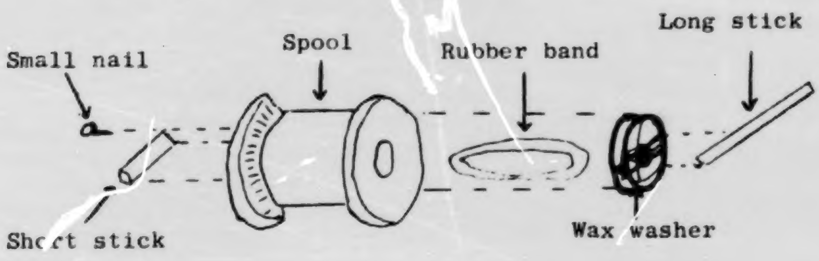
Step 2: Cut a ¼" round slab of wax. The end of a candle can be used for this. Bore a hole in the center and notch one side.

Step 3: Thread the rubber band through the wax washer and the hole in the spool; loop it over the large stick at the end with the wax washer and over the small stick at the end with the nail.

Step 4: Wind the large stick about 10 to 20 turns, place on a flat surface, and release. The spool should move forward at a slow even rate.

Step 5: Experiment with more turns and fewer turns.

Step 6: Experiment with thicker and thinner rubber bands, lengthening or shortening the long stick.



Answer the following questions concerning energy production and work done:

1. What is the spool's source of energy?
2. What is the spool's rate of speed in:

   a. mm/sec b. cm/min c. m/hr

3. What can be done to increase the speed of the spool?
4. What limits the top speed? (Slippage of spool--a thick rubber band tightly wound will exhibit this.)
5. How long does the spool keep moving?
6. What can be done to make the spool run longer?

Make improvements on the basic design that will increase power and efficiency.

Make graphs of

1. Number of turns versus speed
2. Length of longer stick versus speed
3. Number of turns versus running time

for each of three thicknesses of rubber bands and three stick lengths.

Evaluation: Ask each student to write down what should be done to achieve

1. Greatest speed
2. Longest running time or distance

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ACTIVITY 6

Learning: Demonstration of storage and recovery of energy by doing work against gravity; reinforcement of potential kinetic energy.

Materials: Marbles, sentence strips, measuring tapes, 1 x 2 x 3 (approximately) wooden blocks, one pound of fine sand

Teacher Information: This activity will reinforce previous concepts. It is understood that not all aspects of force, energy, work, etc., will be discussed in this activity. A sound basis for later activities can be developed as this activity may be reworked for further understandings.

Procedure: Fold two pieces of sentence strip in half lengthwise to make a long V-shaped ramp. Tape the two pieces together for strength.

Spread sand in an area about 8" by 8". Using a ruler, smooth it to about a 1/8" thickness.

Elevate one end of the ramp by placing it on top of a 2.5 cm (1 inch) block. Lift a marble, place it at the high end of the ramp, and allow it to roll down into the sand.

Discuss the motion of the marble asking where its energy came from. Make sure everyone understands that the energy of the rolling marble (kinetic energy) comes from the energy stored by lifting the marble against gravity (potential energy).

Measure the length of the track in the sand. Move the ramp to one side so that it leads to a fresh area of sand.

Elevate the ramp to 5 cm (2 inches) and allow a marble to roll down into the sand. Measure the length of the track in the sand.

Repeat with the ramp elevated to 7.5 cm (3 inches). Graph the tracks versus the ramp heights. Discuss the differences in track length as indicators of differences in energy. Ask where the differences in energy came from. (See that they understand that it is due to differences in height of the marble at the start. Differences in ramp height are not the actual cause.) The higher the marble was lifted, the more energy we put in. The energy we get out of a storage system is proportional to the amount we put in.

Extended Activity: Repeat the experiment using a styrofoam ball and a steel ball bearing rolling from a single height. Note that the energy in the styrofoam ball is less than that of the marble and that of the steel ball bearing is more. Relate these to the differences in work required to lift the styrofoam ball and the steel ball bearing to the height of the ramp. The amount of energy we get out is proportional to the amount of energy we put in.

ACTIVITY 7

Learning:	Combustion is the burning of anything. It releases energy stored in the elasticity of the chemical bands of the material being burned.
Materials:	Safety matches
Teacher Information:	Combustion is a chemical process of breaking molecules apart, accompanied by the production of light and heat; an act or process requiring a fuel and oxygen which, when combined together and kindled with heat, react vigorously, giving off heat. This process is commonly called burning.

Materials which are inflammable are usually composed of fairly complex molecules (groups of atoms) tied together by chemical bonds, which are a form of electrical attraction. These bonds are like stretched rubber bands, pulling together atoms which would otherwise repel each other and fly apart. When the material is burned, the bonds are severed and the energy stored in their stretched state is given off as heat. How does the energy get into the bonds? When a tree grows, photosynthesis provides the energy to assemble its molecules, and part of that energy is stored in the chemical bonds. The energy in fossil fuels is the same kind of chemical bonding energy, stored during the lifetime of the prehistoric plant or animal whose remains became coal or petroleum.

Procedure:

1. Observe a match; identify the head, which contains chemicals.
2. Ask: "As you strike the match, what kind of energy is involved?" (Mechanical from arm movement and heat from friction.)
3. Ask: "What is heated?" (Chemicals in head of match.)
4. Strike match; when chemicals (in head) are heated to a temperature at which they react, more heat is generated. Since heat cannot escape quickly into the air, the chemicals burn with a flame.
5. The heat from the flame raises the temperature of a layer of the matchstick and the oxygen near it, and the wood and oxygen react in combustion; the match burns.
6. Demonstrate striking a match in a windy area. If the match goes out, it is because the wind blew away the heat, so that the temperature was not raised sufficiently.
7. Drop the burning match onto a glass or ceramic surface. When it goes out, closely examine both the match and the surface.

8. If you look closely, moisture will be observed on the surface. The match is obviously no longer wood (or paper) but has become something different--charcoal.

Evaluation: Discuss what burns with the class. Point out that most of the objects named are organic in origin and that the energy contained in those objects is a result of photosynthesis. (Note: Some non-organic items also will burn. These objects burn as a result of molecules breaking apart, but they were not produced by using solar energy. An example would be the burning of the metal magnesium.)

OBJECTIVE 2: *Students will be able to give examples of forms and sources of energy, renewable and non-renewable energy sources, and the conversion and loss of energy.*

ACTIVITY 8

Learning: Solar energy is required, directly or indirectly, by living organisms.

Materials: Carbon paper, geranium or similar large-leafed potted plant

Teacher Information: The sun is the ultimate source of nearly all of the energy consumed on earth. (The exception is nuclear energy.) Most people are unaware of this, because the manner in which solar energy comes to our use is frequently obscured by intermediate steps.

Two rather direct processes, convection and evaporation, were demonstrated in Objective 1, Activity 2. Convection makes the sun's energy available to us quickly and more or less continuously. Heat is converted to air motion, but there is no significant storage of energy. As in the pinwheel and lamp demonstration in Activity 2, wind energy depends on continued heating. Evaporation also depends on continued heating, but at any given moment there is an appreciable amount of energy stored in water previously lifted which has not yet returned to sea level.

The most important process through which solar energy comes to our use is called photosynthesis. Photosynthesis is the process by which every green plant is able to use solar energy *directly* to do the work necessary to build its own complex molecular structures from the simpler molecules in the plant's environment. This process is important because (1) it is the beginning of the food chain, which provides energy to all other living things, and (2) it is the origin of all fossil fuels.

If plants provide fuel for the other living things, it follows that the growth of plants must be a process of energy storage. The energy is stored in the chemical bonds which hold the plant's molecules together. It is put into storage when the molecules are assembled during growth. It may be taken out by digestion, combustion, or any other process which disassembles the molecules.

What we now know as fossil fuels are ancient deposits of plant and animal life. Coal has been changed by varying amounts of time, heat and pressure to its present high carbon content forms. Petroleum consists of the remains of marine plants and animals which, though long dead, still contain large, complex molecules whose connecting bonds yield abundant energy when the bonds are broken. This biological process yields food as well as fuel.

Every living thing on earth which does not have photosynthesis capability *must* feed, directly or indirectly, on things which do. Every animal, for example, eats either vegetable matter, or it eats other animals which eat vegetable matter. This transfer of energy can be observed by looking at specific food chains and food webs.

Procedure: Fold a piece of carbon paper all the way around three big leaves. Use paper clips to hold the carbon paper in place. Write down the date, perhaps on the class calendar. Put the plant in a sunny place. Water the plant as usual. After five days take the paper off one leaf. Study the leaf. In what way does it look different from the other leaves on the plant? Keep the carbon paper off this leaf. After two more days take the carbon paper off another leaf. Study this leaf. How is it different from the other leaves on the plant? Leave the carbon paper on the third leaf until the leaf falls from the plant. Then study the fallen leaf. What happens to a green leaf when it is kept in the dark?

Ask students to identify the one change that was made for the three leaves. (Sunlight blocked by carbon paper. This is the manipulated variable.)

Ask students to identify what changed as a result of the leaf getting no sunlight. (Color change, eventual wilting and falling from the plant. This is the responding variable.)

Ask students to identify what variables were kept the same for all the leaves on the plant, uncovered and covered. (Warmth, water, nutrients from oil or fertilizer.)

Conclude that without light energy green plants cannot survive.

Brainstorm with the class to list a variety of animals.

Given the terms

carnivore
omnivore
herbivore

identify animals which belong to each group.

Discuss how *all* animal life depends upon plant life.

Evaluation: Have each student write a paragraph telling how life is dependent on solar energy. (The flow of energy through food chains should be mentioned.)

ACTIVITY 9

Learning: The sun is the source of energy for all living things. Green plants change sun energy to food energy. A food chain is the sequence of energy transfer from organism to organism in the form of food. Food chains intertwine to form food webs.

Materials: String, paper, pencils, crayons

Teacher Information: As food energy flows from one living organism to another in a food chain, more and more energy is changed to heat energy, much of which living things cannot use. The sun is our source for more energy. Green plants which convert solar energy to food by photosynthesis are the primary food source in a food chain.

Of the sun's energy 50% is reflected back into space by clouds and dust; 20% is abosrbed by the atmosphere; about 30% heats the land and water. Two percent of the sunlight reaching the earth is used by green plants in the process of photosynthesis. (*Chains, Webs, Pyramids* by L. Pringle and J. Adkins, Crowell)

Nutrients such as minerals and other elements which are necessary for normal growth of plants and animals are recycled.

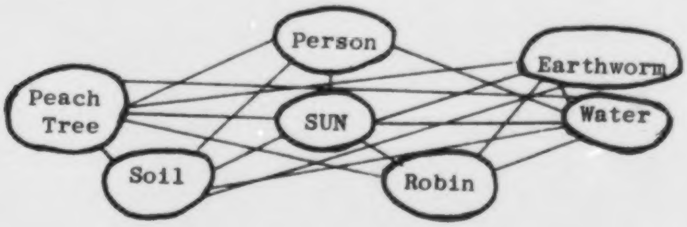
Decomposers, bacteria and fungi, get energy from the food chain by breaking down the remains of once living plants and animals.

Procedure: Assign each student to part of a food chain, i.e. Bermuda grass, white crowned sparrow, earthworm, etc. (Green plant plant eater animal eater 1 animal eater 2, etc.)

Have students draw a picture of that part of the food chain and label the picture.

Have students form a circle with pictures pinned to chest.

Connect consumers and producers and abiotic materials with string thus:



Pull the web tight and discuss what happens to the relationships when one part of the ecosystem is removed.

Evaluation: Can students identify the primary energy source in a food chain? The primary food source? Solar energy and green plants must be present in any food chain or food web.

ACTIVITY 10

Learning: The energy which reaches us from the sun may be divided as follows:

1. Energy which is continuously available. We can use it all without using it up.
2. Energy which is replenished fairly rapidly. If we are careful, it won't be used up.
3. Energy which takes so long to replenish that once we use it up, we won't live until it is replenished.

Materials: Available reference material: encyclopedias, library books, sound strips, etc. on fossil fuels.

Teacher Information: The energy in wind and falling water is constantly replenished by the sun (during daylight hours). Recalling the analogy given in Objective 1, Activity 3, these continuously available sources of energy are like a salary paid at regular intervals. In contrast, let us look at vegetation, a savings account which is often replenished, and fossil fuels, a long-term savings account.

Let us contrast vegetation and fossil fuels as energy storage media, in the light of the energy analogy given in Objective 1, Activity 3.

Vegetation is a quickly replenished savings account for energy. Wood can be produced in a generation or less. A substantial amount of alcohol can be produced by fermentation of a single year's crop of a starchy material, such as potatoes. Both wood and alcohol can be burned to produce steam, which, as we know, can do a lot of work. Alcohol can also be used in automobile engines. So long as we don't use it faster than nature can produce it, this sort of energy is inexhaustible.

In contrast, fossil fuels, such as coal and petroleum, were formed millions of years ago, and required at least tens of thousands of years to form. Most important, they are being replenished, if at all, at a rate which would require us to wait hundreds of generations for new deposits to form. Imagine a checking account containing a million dollars which is replenished at a rage of $500 a year. It seems like a lot, but once the balance is spent, it will take many lifetimes to replenish it. Fossil fuels are non-renewable in the sense that neither we, nor our great-great-grandchildren, nor any later generation we can imagine, will be around to see them replaced. There is a lot of controversy as to how much fossil fuel is left on earth, but it seems clear that, at our present rate of consumption, we will use up in two to 10 generations the energy savings that it took hundreds of generations to accumulate.

Procedure: Assign individuals or groups a fuel (coal, wood, petroleum, peat, natural gas, methane, diesel fuel, alcohol) on which to report. Each report might include the information on where it can be found and methods used for extraction, transportation and storage.

After reports have been presented, discuss with the class the three statements in the Learning:

1. Energy which is continuously available. We can use it all without using it up.

2. Energy which is replenished fairly rapidly. If we are careful, it won't be used up.

3. Energy which takes so long to replenish that once we use it up, we won't live until it is replenished.

Into which category does each fuel fall? Have students support their choice.

Evaluation: Have students state in their words the significance of the terms "renewable" and "non-renewable energy sources."

ACTIVITY 11

Learning: Food, wind, coal, oil, natural gas, water cycle--all require solar energy. Heat, light, and/or motion are evidence of energy in use.

Materials: Paper, pencils, encyclopedia

Teacher Information: See teacher information in Objective 1, Activity 2, page 3.

Procedure: To show necessity for solar energy (use reference books as needed) have each student:

1. Select one energy source (food, coal, oil, natural gas, water cycle, wind).
2. Prepare a diagram to illustrate the necessity of solar energy to the energy source.
3. Write a paragraph telling how solar energy is required by this source and why this source is considered renewable or non-renewable.

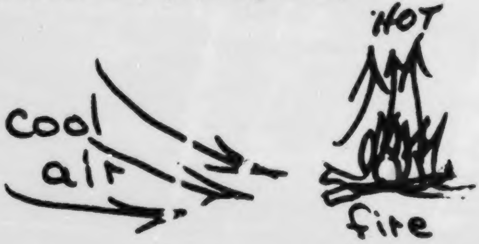
Evaluation: Have students identify evidence of energy use (heat, light, motion) in their diagrams. Is the role of the sun's energy clear in students' diagrams and paragraphs?

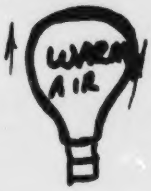
ACTIVITY 12

Learning: Warm air rises as cooler, heavier air pushes downwards, crowding the warm, light air upward.

Materials: Birthday candles (or similar small candles), matches, 3"x5" index cards, needle, plastic straw, one 2"x4"x8" piece of wood.

Teacher Information: Warm air is lighter than cool air. When the air in one area is heated, the cooler, heavier air replaces the warmed air by moving in and under it, pushing it up.

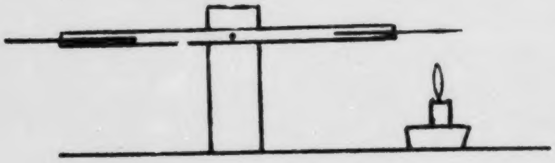




Hot air ballons rise because the air inside them is "lighter" than the air that surrounds them. Glider pilots fly to areas where they believe a "thermal" exists because its warmer, rising air will carry them upward. (They may look for freshly plowed fields, large asphalt parking areas, etc., since these will become hot from the sun's energy, warming the air about them.)

Procedure: Construct your "heat riser" device (USE CAUTION WITH FLAME):

1. Cut the straw at both ends so 3"x5" cards will be able to slide horizontally into the ends.
2. Insert the cards.
3. At the middle of the straw, insert the needle so the straw and cards balance. (The cards may be shifted until a balance occurs.)
4. Push the needle into the 2"x4"x8" near the top of one of the sides.
5. Place the candle into the aluminum food container and light it.



Observe what happens to the "heat riser."

Reverse the ends of the testing device and observe results.

Evaluation: Have students write a statement which explains their observations.

Extended Activity: Discuss the following information with the class:

> Heated air rises as it is replaced by cooler, more dense air. Cooler air, rushing to fill in places where warm air is rising, frequently causes wind currents.
>
> In California, the Central Valley in summer frequently reaches 25-35° Celsius. The air along the coast of California is cooler and heavier. The cool air is blocked by mountains, so it can't rush in to replace the warm air. In the area around San Francisco, there are no mountains where the rivers flow to the sea. In summer, cool air rushes through this break in the mountains called the Straits of Carquinez. This rushing air causes the frequent summer winds for which San Francisco is known.

ACTIVITY 13

Learning: Solar energy heats up differing surfaces at differing rates.

Materials: Thermometers, paper, pencil

Teacher Information: Solar energy heats the surface of the earth. Surfaces retain heat at differing rates. The collection, storage, and conversion of solar energy is dependent in part on the amount of heat energy that can be produced. Have the students measure the temperatures around the school to find areas where solar energy has caused an area to accumulate the greatest amounts of heat energy.

Procedure: Write "solar energy" on the board.

Discuss that solar energy is energy coming from the sun. It can cause sunburns, tans, etc. It is needed for plants to grow. It keeps the earth warm.

Say: "Today we are going to measure the heat in solar energy."

"Measure areas outside and find the warmest and coolest spots on the school ground."

Evaluation: Ask: "Where were the warmest areas? Coolest areas? Did sunny and shady areas have the same temperature? Did surfaces of different colors have different temperatures?"

Definitions: "Temperature" is the average energy (molecular motion) of a substance. "Heat" is the total energy absorbed. *Concepts in Science* (Grade 6), Lab Investigation 42, page 122, further develops the distinction between heat and temperature.

ACTIVITY 14

Learning: Solar energy can be concentrated by using a collection device.

Materials: Pattern (Appendix A-1), scrap cardboard, glue, paper fasteners, aluminum foil, tracing paper, punch, scissors, pencil, thermometer

Teacher Information: Many people are experimenting with ways to better collect the sun's energy to use for work and heat. This solar heater is similar to a solar furnace which is a curved mirror that focuses sunlight into a small area.

This solar heater, or hand warmer, can be used to concentrate the sun's heat. Aim the solar heater directly toward the sun. The heat will be most intense a few inches from the center. (As the sun changes position, re-position the solar heater every 15 minutes or so.)

Procedure: Find 10 pieces of scrap cardboard of similar thickness.

Glue aluminum foil (shiny side up) to each cardboard piece. (Keep as smooth as possible.)

Trace the leaf shape *exactly* onto each of the 10 cardboard pieces. Mark the position of the holes.

Carefully cut out the 10 leaves. Punch the holes with a paper punch or point of pencil.

Stack the leaves, foil side up. Attach all 10 at the base with a paper fastener.

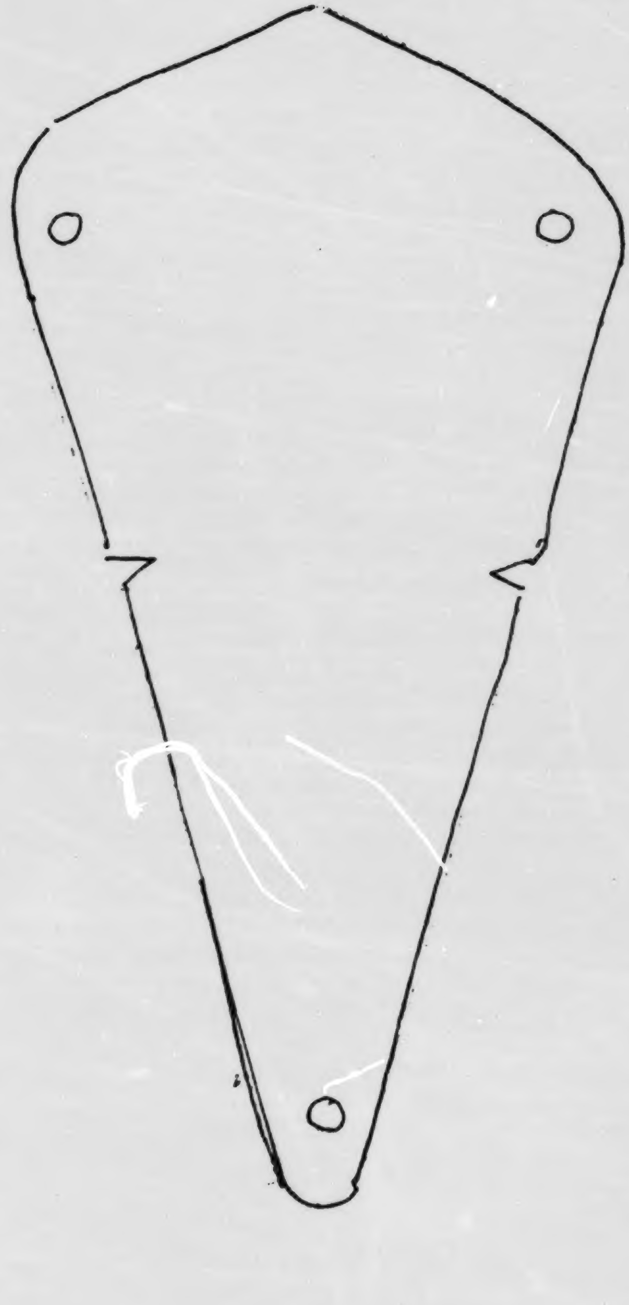
Attach the leaves, starting at the top, fitting notches together. You will have to bend the leaves to line up adjoining holes.

When all are attached you are ready to use your solar heater.

Measure the air temperature in the center of the solar heater. Compare this temperature with the temperature of the air outside your solar heater.

Concentrate the sun's energy with a magnifying glass.

Evaluation: Discuss the importance and uses of concentrated solar energy.



ACTIVITY 15

Learning: Solar energy may be used in a variety of ways.

Materials: Tin cans; thermometer; paint, white and black

Teacher Information: Solar energy is currently being discussed because we realize that the sources of fuels we have so commonly used are becoming more scarce. We realize that our world must place its dependence upon sources of energy that are constantly being replenished and are not harmful to the environment. Solar energy is believed by some to be a viable alternative, when coupled with conservation, to other sources of energy.

Solar energy has been used by the plants and animals of the earth for millions of years. Plants require solar energy for photosynthesis. Animals eat plants and so indirectly use solar energy to maintain their body temperatures. Humans also have relied upon the sun's heat energy (solar energy) for thousands of years. The Indians of New Mexico, Colorado, and Arizona built their cliff dwellings facing the sun. In winter the rays slanted beneath the overhanging cliff to warm the structure. During summer, the sun (being higher overhead) would shine onto the cliff, placing the dwellings in cooler shade. The adobe building blocks, common in many areas, are dried by the sun's energy. Fruits and meats have also been dried by people for later use.

Current discussions on the use of solar energy center around two major uses: (1) heating--for heating spaces (homes), for cooking, for hot water to be used in a wide range of applications, (2) for conversion directly into electricity using photovoltaic solar cells.

Spacecraft have used solar energy both for heating and for the production of electricity. With the current levels of technology, the production of large amount of electricity using solar cells is impractical. The cost of large solar cells is very high. The surface areas required to produce large amounts of electricity would be very large. Satellites orbiting the earth with square miles of solar cells have been proposed. However, the high energy cost to lift the satellites into orbit and the cost of construction suggest that with our current technology these satellites may not be practical.

Procedure: Here are several suggested activities:

1. Discuss the teacher information with the students.

2. Paint two cans--one black, one white. Fill both cans with water. Place a thermometer into the water and put both cans in the sunlight. Measure the water

temperature in each can at 15-minute intervals for two hours. Record the observed temperatures. Ask: "What happened to the temperatures in the white can? The black can? Which can heated more rapidly?"

3. Have the students bring in an object they feel will store solar energy in any form (light, heat, mechanical, chemical--plants, rocks, cans of water, etc.).

Evaluation: Solar energy may be converted into energy forms useful to people. It is renewable and may be stored as heat or chemical energy.

ACTIVITY 16

Learning: Petroleum is refined to produce products that we use in a variety of ways.

Materials: Diagram of refinery (Appendix A-2), encyclopedia and/or trade books on petroleum.

Teacher Information: Petroleum is a mixture of many different compounds. Many of these are made of hydrogen and carbon and are known as hydrocarbons. The molecules in some hydrocarbons are simple, others are quite complicated. Most of the weight of the hydrocarbon is in the carbon atom. The more carbon, the heavier the hydrocarbon molecule.

At ordinary temperature, the heaviest hydrocarbons are solids (asphalt), the lightest hydrocarbons are gases, and the rest are liquids.

Heat can cause the solids to melt into liquids and the liquids to evaporate into gases.

People produce many products from petroleum. Gasoline is one such product. It can be produced by three processes:

1. Fractional distillation, which separates the gasoline molecules from the heavier hydrocarbon molecules.
2. Cracking, which produces gasoline by *breaking* the heavier hydrocarbon molecules.
3. *Polymerization*, which *joins* lighter hydrocarbon molecules to produce gasoline.

This activity involves the study of a fractionary tower diagram and using encyclopedias to research information about the products resulting from the fractionary process, including petrochemicals.

Petroleum is also used as a raw material to produce petrochemicals. These chmicals form the bases for thousands of products which include plastics, man-made fibers, synthetic rubber, detergents, and solvents. Many of the chemicals may also be obtained from coal, coke, and other vegetable products.

Procedure: Give each child a copy of the refinery tower diagram.

Discuss the diagram with students. Refer to teacher information.

Inform students that petroleum is also used as a raw material for petrochemicals.

Assign the following topics for groups and individuals to report on:

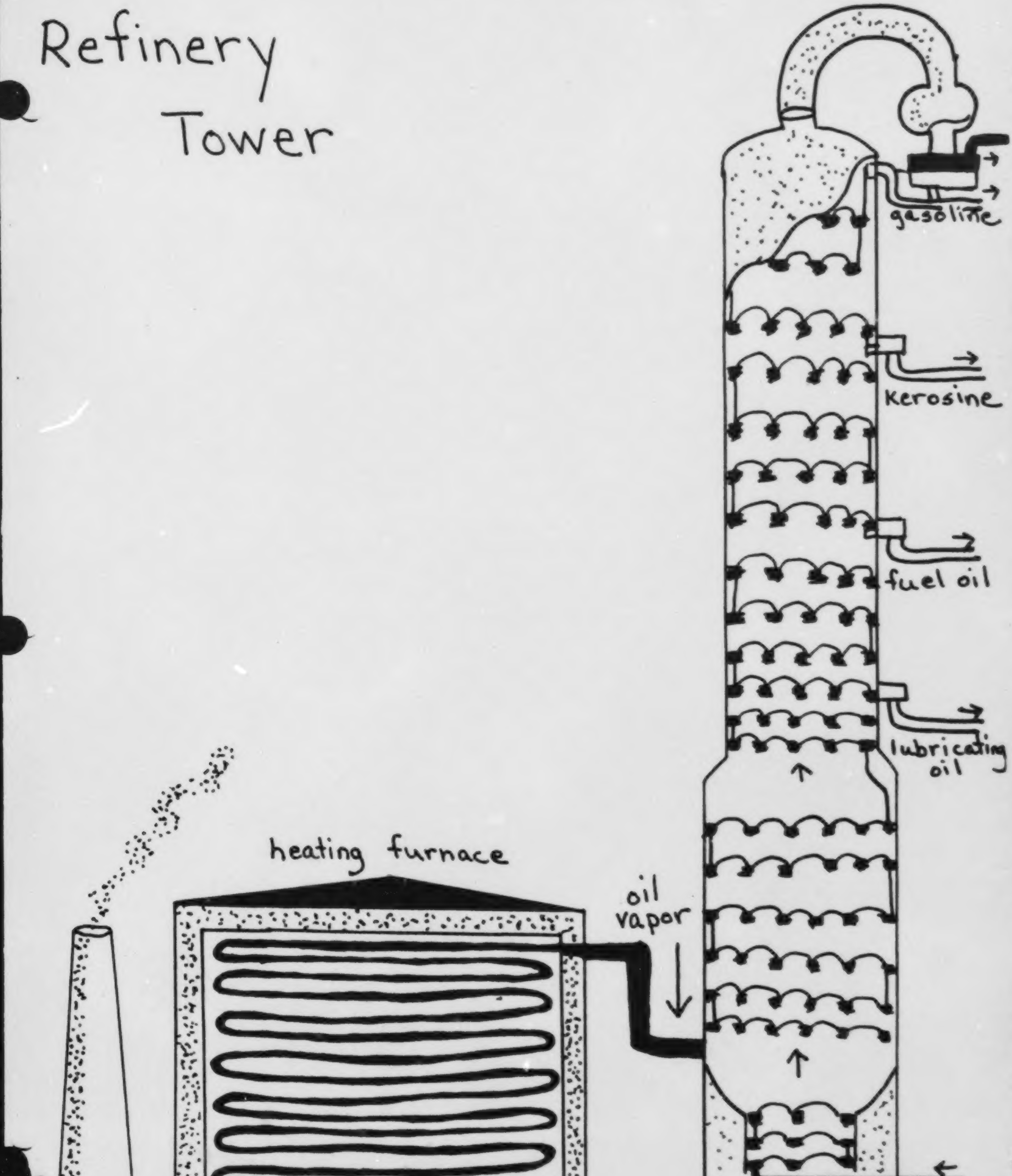
Asphalt
Fuel Oil
Kerosene/Kerosine
Gasoline
Lubricating Oil
Gas Oil
Diesel Oil
Petrochemicals

Have them research any or all of these topics.

As students read about their topics, they should identify any way in which that product is a part of their lives (e.g., directly, as in gasoline for transportation, indirectly, as in diesel fuel used to transport food).

__Evaluation__: Can students name 10 petroleum products or uses of petroleum that are important to their lives?

Refinery Tower


gasoline
kerosine
fuel oil
lubricating oil
heating furnace
oil vapor
steam
asphalt

ACTIVITY 17

Learning: Petrochemicals are used to make fabrics.

Procedure: Say to the children, "Did you know that many of you are wearing oil?" Explain that we call material made from oil by-products synthetics. Have them name some synthetic materials (nylon, dacron, polyester).

Ask, "What other material is clothing made from (wool, cotton, silk)?" Have the class examine the labels of shirts, blouses, jackets, sweaters, etc., that they are wearing.

Put the following headings on the chalkboard:

WOOL COTTON SILK SYNTHETIC

Tally the number of garments in the classroom that are made from the respective materials on the chalkboard. Ask, "Which of these materials seems to be used most? Least? *Why* do you suppose this is true?" (Synthetics are easy to care for.)

Say: "Oil is also an energy source in our country which is becoming more scarce. Considering the growing shortage of this source of energy (oil), how do you feel about most of our clothing being made from synthetics?" (Be sure to get *reasons* for these feelings.)

Invite someone who is familiar with various fabrics to bring in samples and describe the characteristics of each. (Suggestion: Contact a store specializing in knit fabrics such as Fabric Showcase, Stretch-Sew, or a home economics teacher.)

Evaluation: Have students identify uses of synthetic fabrics.

ACTIVITY 18

Learning: Nuclear fission and nuclear fusion are two different processes which result in the release of energy.

Materials: Work sheet, set of statements, science dictionaries, encyclopedias, books on nuclear energy

Teacher Information: These definitions are supplied for teacher information. Students can use research materials at their reading level to find definitions. They should be encouraged to make diagrams or act out meanings of terms.

Terms to be defined by students:

1. Fission
2. Fusion
3. Nuclear reactor
4. Atom
5. Proton
6. Neutron
7. Nuclear chain reaction
8. Uranium, plutonium, and thorium
9. Radioactivity
10. Breeder reactor

Definitions for teacher use:

1. *Fission.* The splitting of atoms of uranium, thorium or similar heavy atomic nuclei, releasing energy as in an atomic reactor.

2. *Fusion.* A process by which the nuclei of hydrogen atoms are forced together to make the nuclei of heavier atoms, thus giving off energy.

3. *Nuclear reactor.* A device capable of maintaining a self-sustaining controlled nuclear fission reaction; a pile of atomic fuel such as uranium or thorium, intermingled with a moderator such as graphite or heavy water which is used to control the rate of the reaction.

4. *Atom.* The smallest particle of matter that can exist and not remain a chemical substance when divided further; made of electrons, protons, and neutrons. Atoms often cling together to make molecules.

5. *Proton.* A tiny particle with a positive electrical charge, of which, together with neutrons, the nuclei of atoms are made.

6. *Neutron.* An uncharged particle of which, together with protons, the nuclei of atoms are made. Neutrons are very tiny and pass through matter easily.

7. *Nuclear chain reaction.* A sequence of nuclear fissions, each initiated by a neutron from a preceding fission.

8. *Uranium.* Basic fuel for nuclear energy, a somewhat rare radioactive chemical element.

   Plutonium. A radioactive chemical element used as fuel in nuclear reactors, extremely rare in nature, but can be made in breeder reactors.

   Thorium. A rare, grayish radioactive chemical element used as fuel in nuclear reactors.

9. *Radioactivity.* The property of giving off or being capable of giving off high energy rays and subatomic particles.

10. *Breeder reactor.* A nuclear reactor that produces more nuclear fuel than it consumes.

Procedure:

1. Assign one term or pair of terms to individual students to define.

2. Individual students present their definitions to class. Class members may take notes.

3. Using these notes, class members complete a teacher-made work sheet which requires the matching of terms and definitions.

4. Discuss work sheet.

Example of work sheet:

Match the terms and definitions by writing the number of the term next to the correct definition.

1.	Breeder reactor	____	involves a putting together of nuclei of light atoms to produce energy
2.	Fission	____	a nuclear reaction kept going by the fission of nearby nuclei
3.	Fusion	____	a particle of an atomic nucleus with a positive charge
4.	Nuclear chain reaction	____	fuels which may be used in nuclear reactors
5.	Nuclear reactor	____	involves a splitting of nuclei of heavy atoms to produce energy

6. Neutron	____ a particle of an atomic nucleus with no electric charge
7. Proton	____ a nuclear reactor that produces more nuclear fuel than it consumes
8. Radioactivity	____ a device for maintaining a controlled nuclear fission reaction
9. Uranium, plutonium, and thorium	____ giving off of high energy rays and subatomic particles

Evaluation: Given the following statements describing nuclear fission and/or nuclear fusion, have students sort them under the two headings, "Nuclear Fission" and "Nuclear Fusion." Discuss.

NUCLEAR FISSION	NUCLEAR FUSION
1. Uses heavy elements as fuels	1. Could use seawater as a fuel
2. Splits atomic nuclei	2. Joins nuclei of light atoms to make heavier atoms
3. Has radioactive by-products	3. Is free of radioactive waste material
4. Is being used to generate electricity in some places	4. Scientists are working on the problems of releasing this energy slowly
5. Is used to power some submarines	5. Is the kind of reaction that gives the sun its heat
6. Is currently being used	6. Is currently being developed

ACTIVITY 19

Learning: Nuclear power plants obtain their energy when atoms are split.

Materials: Glass or plastic tumbler, cooking oil, teaspoon, butter knife, rubbing alcohol

Teacher Information: In 1976, 54 power plants across the United States were using nuclear power to produce electricity. Almost one-tenth of all electricity produced in the United States is generated in these plants.

All matter is made up of atoms joined in different combinations. Under the right conditions certain atoms may be split into smaller atoms. Natural radioactive decay is a process whereby an atom emits a series of small particles and radiation that form one or more smaller atoms. There are many atoms that break apart spontaneously. These substances are called radioactive.

When an atom breaks apart it releases energy. The energy from radioactive decay has specialized uses (medical therapy, etc.) but is not recoverable as a commercial energy source. Nuclear power plants capture the heat energy produced in fission reactions and use it to generate electricity.

Atoms are extremely small and have never been seen even through powerful microscopes. Scientists have observed how an atom behaves as it splits. This experiment illustrates that procedure.

Procedure: Say: "Nuclear power plants capture heat energy that is given off when atoms split in two. Atoms are the very tiny building blocks for every thing on earth. It would take 200 million atoms side by side to reach one inch."

"Since we can't see atoms, we are going to use a model to see how an atom behaves as it splits."

Fill the glass about one-half full with rubbing alcohol.

Add enough water to fill the glass two-thirds full and stir.

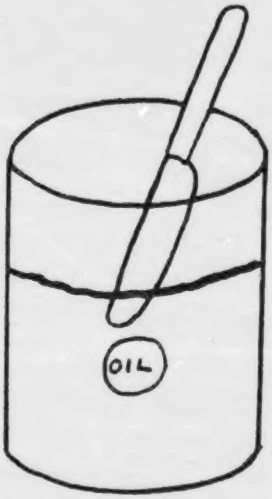
Wipe the teaspoon dry and fill it with cooking oil.

Carefully tip the spoon over (from very close to the surface). A blob of oil should form and float somewhere in the middle of the liquid. If it is on the surface, add a bit more alcohol. If it sinks to the bottom, add a little water.

See how perfectly spherical the drop is. The forces holding the sphere together are similar to those holding an atom together.

Now take the butter knife and carefully push the drop apart. Note that the drop must bulge severely before it breaks apart. We believe atoms behave in much the same way.

Evaluation: Nuclear power plants try to harness the energy given off when certain atoms split apart in a chamber called a reactor. These plants use a process called fission in which atoms are split apart.



ACTIVITY 20

Learning: Energy is released when atoms are split in a chain reaction.

Materials: Domino sets

Teacher Information: In nuclear power plants the uranium 235 isotope (a uranium atom that has 143 neutrons rather than the more common number--146) is used to create a nuclear chain reaction. Uranium 235 is used because it is easily split when bombarded with neutrons acting like bullets. As the atom splits, two smaller atoms are formed, a substantial amount of energy is released, and more neutrons are released. The energy released is highly important in the production of heat to be converted into electricity.

The neutrons released strike additional atoms with the same results causing a chain reaction. If this chain reaction takes place quickly, an enormous amount of energy is released. For the purposes of providing steady energy the chain reaction is controlled in a nuclear power plant. The reaction takes years to complete instead of fractions of a second as in a bomb.

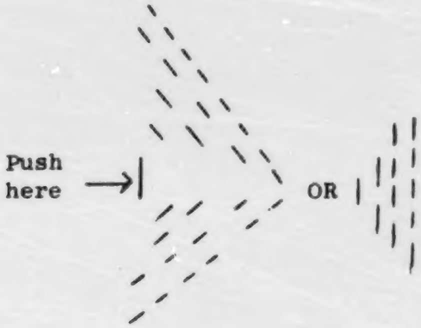
The two types of reactions may be shown with dominoes.

Procedure: Nuclear power plants obtain energy when atoms are split. An atom is the building block of all matter. They are so small that they have never been seen even with powerful microscopes.

In the previous activity you saw how an oil drop model of an atom may be split by the knife blade. In a nuclear power plant, the atoms are split by shooting little bullets called neutrons at the atom. These neutrons are actually parts of atoms. The effect they have on an atom is very similar to shooting a marble into a group of marbles.

Power plants use the chain reaction caused as the neutrons produced break additional atoms apart.

An example of a chain reaction where no controls are placed on the reaction may be shown with dominoes. Each domino represents an atom. Set the dominoes on their sides in the following pattern:

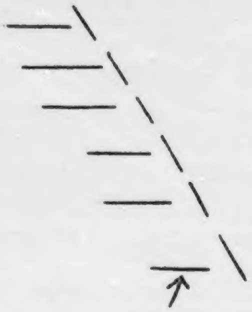


Note: Be sure the dominoes will touch each other when they tip over. The more dominoes available, the more dramatic the results.

This chain reaction releases enormous amounts of energy extremely quickly. This is the basic idea behind atomic bombs.

Atomic bombs would serve no useful function in developing energy for conversion into electricity. In a power plant the chain reaction is controlled so a steady amount of energy is released over a long period of time. In this type of reaction not all of the neutrons released hit other atoms. Some of them are instead absorbed by control rods so the chain reaction may continue for years.

To show this type chain reaction the dominoes are set up in this pattern:



Note: The parallel dominoes must be able to hit each other as they fall plus one of the second group. The second group of dominoes will not hit others down.

To illustrate the differences in the timing of these domino chain reactions, a stop watch is useful. Have the different chain reactions set up several times. Time the reaction times. Use the same number of atoms--dominoes--for each of the chain reactions. Accurate timing is difficult with small numbers of dominoes. Setting off both types of reactions at the same time will help students see the different reaction times.

Evaluation: Energy is released in chain reactions in nuclear power plants. Sound energy was released in the domino reactions. The sound energy was not useful to us from a power conversion point of view. The energy produced in the nuclear reactions is heat. The heat may be converted into electrical energy.

ACTIVITY 21

Learning: Energy is often converted from one form to another, either naturally or through the efforts of people.

Materials: Energy Conversion charts (Appendix A-3)

Teacher Information: The forms of energy are somewhat arbitrary divisions of a single thing: energy, which is the capacity to do work. These divisions are useful in predicting the properties of a particular form of energy, or in understanding where certain energy comes from. Related to the concept of forms of energy is the knowledge that energy can be converted from one form to another. Energy conversion takes place all around us all the time. Conversion processes are the link which connects the systems which consume energy (living things, geophysical systems such as weather, machines, etc.) with earth's primary energy source, the sun.

Heat energy is converted to mechanical energy during evaporation, in that water is lifted, and during convection, in that air is set in motion. Light energy is converted to chemical energy during photosynthesis. A flashlight cell releases electrical energy which it converts from chemical energy stored in it during manufacture. Electrical energy is, in turn, converted to light and heat energy in the flashlight bulb.

Energy which is stored is more difficult to observe than is energy in action. For example, any combustible material is a storehouse of chemical energy. It is only when the energy is released, in the dramatic display of fire, that we become conscious of its presence.

Procedure: List energy forms (heat, light, chemical, mechanical and electrical). Ask students for examples of each (heat and light--sunlight; chemical--batteries or food; or fuel; mechanical--motion of anything; electrical--any working electrical device).

Identify conversion from one form to another. See examples on worksheets. When students appear to understand the task, give them 10 minutes or so to begin filling in the charts. At the end of 10 minutes ask students to share their answers.

Assign completion of the charts for the next lesson.

Evaluation: Have students accurately identified examples of each energy form?

Name ______________________ Date ______________

ENERGY CONVERSION

Energy is often converted from one form to another, either naturally or through the efforts of people.

Identify examples of energy conversion from each of the energy forms on the following charts:

MECHANICAL ENERGY		
Situation	Observation	New Energy Form
Sanding wood	Some mechanical energy of sanding is converted to heat energy--my hand gets warm	Heat energy

ELECTRICAL ENERGY		
Situation	Observation	New Energy Form
Lawn mower plugged into electrical socket	Electric energy becomes mechanical energy which moves the blades	Mechanical

CHEMICAL ENERGY		
Situation	Observation	New Energy Form
Batteries in flashlight	Stored chemical energy converted to electrical energy converted to light energy	Light

LIGHT ENERGY		
Situation	Observation	New Energy Form
I am in sunlight	I get warmer	Heat

HEAT ENERGY		
Situation	Observation	New Energy Form
Heated popcorn kernels	Heat energy converted to mechanical energy Popcorn pops	Mechanical

ACTIVITY 22

Learning: Heat energy may be converted into mechanical energy.

Materials: Sturdy scissors, tripod stand CISlab6, heavy duty aluminum foil or aluminum can top, coat hanger, corks, sterno can, assorted pieces of wood, saw, one empty ditto fluid can with lid, Hero's engine model CIS lab grade 6

Teacher Information: Heat energy may be applied and be converted into mechanical energy. This application has been used for years in steam engines and turbine applications. Steam cylinder engines began with Thomas Newcomer's engine in 1705. By 1769 James Watt had improved Newcomer's engine and held several patents for steam engines. These engines continued to be refined and used in new areas. Thus we saw steamships, steam automobiles and steam locomotives. Each of these uses was supplanted in time by the internal combustion engine.

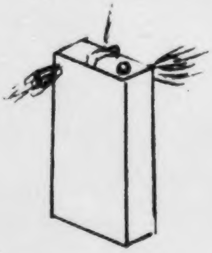
Heat energy applied to water, producing steam for conversion to mechanical energy, continues to dominate in the area of electrical energy. Chemical energy converted into heat energy by the combustion of natural gas, oil, coal continues to power the steam turbines that provide mechanical energy for the generators providing electrical energy. Nuclear power plants provide heat energy which also powers steam turbines and large electrical generators.

The use of heat energy conversion to mechanical energy may be illustrated via the following investigations:

Procedure 1: Discuss teacher information. USE CAUTION WITH FLAME.

Obtain an empty ditto fluid can or Hero's engine (Model CIS lab 6).

Punch holes in the ditto fluid can as shown.



Be sure the holes are unobstructed before heating the can.

Rinse the can out several times with water to remove any remaining fluids or fumes.

Suspend the can from a string at the top so it is directly over the can of sterno (stored chemical energy).

Fill the can about one sixth full with water.

CAUTION: BE SURE TO VENT HEATED CANS.

Light the sterno. Explain that stored chemical energy is being burned and being converted to heat energy.

As the steam begins to turn the suspended can, discuss that the heat energy has been converted into the mechanical energy turning the can. Work is being done. The *force* of the steam is *moving* the can.

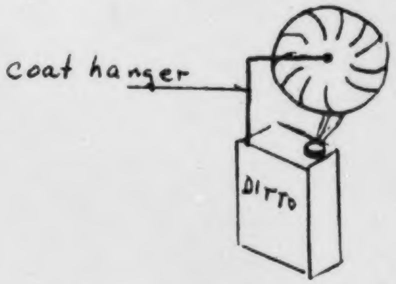
__Procedure 2__: Obtain an empty ditto can, rinse it several times.

Remove the paper sealer from the screw-on lid and punch one hole in the lid.

Be sure the hole is unobstructed before heating the can--UNVENTED CANS CAN EXPLODE.

Have a student build the aluminum foil (or aluminum can) turbine shown.

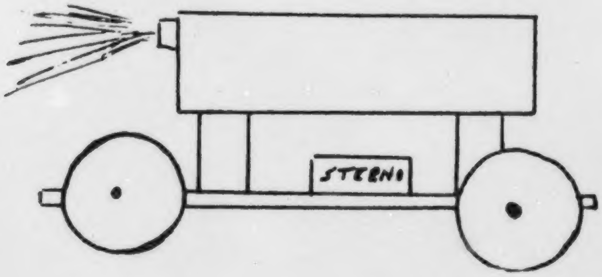
Assemble the apparatus as shown.



Twist each blade on the turbine about 70°. The blades should be fairly equal in the amount to which they have been twisted. The 70° twist is a starting point. The students may wish to have the blades altered after they observe what happens when steam is applied.

Corks pushed into the clothes hanger will keep the turbine blades in place.

__Procedure 3__: Have the students design boats or cans that use steam for propulsion. Models of these may be built using sterno for the heat energy. An example is shown:



BE SURE THE HOLE IS UNOBSTRUCTED *BEFORE* HEATING THE CAN.

__Evaluation__: Have students write a paragraph describing the conversion of heat energy to mechanical energy demonstrated by this procedure.

ACTIVITY 23

Learning: Chemical energy may be stored for use in a later chemical reaction that will release the stored energy.

Materials: Plastic tumblers, soft drink bottle, water, balloon, seltzer tablets, pebbles

Teacher Information: Chemical energy may be stored in a variety of substances. The energy stored in oil, coal, wood, foods, etc. is stored in chemical bonds within the molecules. It was put there when the bonds were made by photosynthesis. The energy may be recovered via a chemical reaction. This reaction may be digestion--in foods, combustion with fuels for engines, etc. Batteries use chemical reactions to store and recover energy. Seltzer tablets have stored energy that may be released in a chemical reaction that is observable to students.

Procedure: Duscuss "storing" as the delaying of usage. Toys are "stored" until they are needed again, food is stored until it is used (eaten).

Fill the glass two-thirds full with water.

Drop in a pebble and observe what happens.

Drop in a seltzer tablet and observe what happens.

Evaluation: Have students identify other examples of chemical energy being released. (Energy use can be identified by the presence of heat, motion or light. Then trace the source of that energy.)

ACTIVITY 24

Learning: Energy loss is inherent in the conversion of energy from one form to another.

Materials: Paper, pencil, incandescent light bulb, thermometer

Teacher Information: While the technical explanation states that energy cannot be used up, from a practical sense this is misleading. A more accurate statement to the students might be that energy is not used up, but it may be changed into a form that is less usable, unwanted or simply useless. For example, an incandescent light bulb creates light as electrical energy flows through the filament, causing it to heat and glow. The *purpose* of the light bulb is to convert electrical energy to light energy. The light bulb also converts the electrical energy into heat energy. About 95% of the energy in a normal incandescent light is converted to heat energy, which is wasted energy unless it is being used to some other end, i.e., heating space, etc. An alternate lighting device which produces less unwanted heat is a fluorescent light.

Some of the examples of energy loss--unnecessary use of energy for a specific task--might be in the heat energy lost as electrical energy is converted: to mechanical energy in a drill, to light energy in a lamp, to sound energy in a radio, to sound and light energy in a television.

Procedure: What is the purpose of a

- person running (exercise or move from one place to another)
- radio (sound)
- television (sound, light)
- drill (making a hole)
- gasoline lantern (light)
- vacuum cleaner (suction)
- automobile engine (moving a car)
- record player or stereo (music--sound)

What form of energy are these examples using?

- radio (electrical)
- television (electrical)
- drill (electrical)
- vacuum cleaner (electrical)
- light bulb (electrical)
- chain saw (electrical or chemical--gasoline)
- automobile (chemical energy, gasoline-burning)
- person running (chemical, food)
- gasoline camping lantern (chemical energy)
- record player/stereo (electrical)

Into what form of energy is the energy being converted?

- radio (sound energy)
- drill (mechanical energy)
- chain saw (mechanical energy)
- person running (mechanical energy)

- light bulb (light energy)
- record player/stereo (mechanical-sound energy)
- gasoline camping lantern (light energy)
- television (sound-light energy)
- vacuum cleaner (mechanical energy)
- automobile (mechanical energy)

Measure the temperature of several examples when "turned off" and when converting energy from one form to another. (Note: People convert energy at all times--it is the increased activity here that is emphasized.)

Compare the temperatures.

Evaluation: The increase in temperatures from "at rest" and when performing the required tasks is a measure of one form of energy (heat energy) that is not necessary and therefore is lost in this transfer. Some energy is lost each time energy is converted from one form to another.

ACTIVITY 25

Learning: Energy is frequently converted from one form to another.

Materials: Automobile

Teacher Information: The automobile provides a wealth of energy conversions the students may study. Have the class examine the car on the playground and looking at the conversions of energy would be useful.

Procedure: Energy is required to make things move, grow, or change. In order to make my car, people took many materials and changed them into a car. To change all of those materials took a lot of energy. (We all know that cars don't come out of the ground--people must make them!)

What do I put in my car to make it go? (gasoline--a form of chemical energy)

How does the gasoline make the car go? In the engine the gas burns rapidly (explodes) and causes parts of the engine to turn which then can move the car. Heat energy converts to mechanical energy. Chemical energy converts to heat energy which converts to mechanical energy.

Why can't I touch my engine after the car has been running and after I lift the hood? (An operating engine produces a lot of heat energy. Some makes the car go, but most is wasted, heats the engine and must be removed by the cooling system.)

When it gets dark I turn on a certain switch and what happens? (The lights go on--light is a form of energy.)

If I touch the light, what do I feel? (heat--unnecessary use of energy--a loss in the conversion to light energy)

Don't lights need electricity? (Caution: Camping lights may use gasoline.)

What about the radio--does it work from electrical energy or gasoline?

The car takes the energy from the engine (mechanical) and turns an alternator or generator (with belts running from near the fan to turn it) to convert part of the energy to electricity. Some of the energy is stored in the battery.

How can a person in a car be more comfortable on a cold day? (Turn on the heater and use some of the excess heat energy produced in the engine for space heating.)

Is energy used in honking the horn? (Electrical energy is converted to sound energy.)

There are other energy conversions the class might like to discuss; e.g., windows rolling up and down, turn signals, steering, brakes. (Avoid kinetic energy--movement of the car--to avoid accidents.)

Evaluation: Have students identify two or more examples of energy conversion in the use of any machine.

ACTIVITY 26

Learning: A review of:

1. *Energy*--the capacity for doing work
2. *Effects of energy*--heat, light, motion
3. *Forms of energy*--heat, light, electrical, chemical, mechanical, and nuclear
4. *Sources of energy*--food, fuel, falling water, wind, which are all ultimately tied to solar energy

Materials: Chart forms, variety of books on energy

Teacher Information: This lesson may take several sessions to complete.

Energy is the equivalent of or the capacity for doing work.

The forms of energy include heat, light, mechanical, chemical, electrical, and nuclear. The distinction between kinetic and potential energy is most often applied to mechanical energy. (Water vapor in a cloud has potential energy stored in it by the sun during the process of evaporation. When the water vapor condenses into rain, kinetic energy is released. When rain water collects on a mountain top, the water has potential energy, which is released as kinetic energy when it flows downhill to form streams, rivers, etc.)

The expenditure (expenditure rather than use, since the expenditure of energy is not necessarily purposeful, e.g., Niagara Falls) of energy can have a number of effects. Some of these effects are directly observable with the senses, and some are not. The most common effects of expended energy which are directly observable are heat, light, and/or motion. To observe the expenditure of chemical and electrical energy may require the use of measurement instruments, which constitutes a kind of indirect observation.

The discussion may be recorded by the teacher on the chalkboard or by each child on a chart during the discussion. Or the children may be asked to do the chart independently after the discussion.

Procedure: 1. Discuss a phenomenon in which there is an *observable* expenditure of energy (heat, light, motion). Suggestions: Candle burning, person exercising, fan on. Record these observations on the chalkboard or chart.

Phenomenon	Observed Effects
burning candle	heat, light
moving pinwheel	motion
exercising person	heat, motion

2. Discuss the form of energy used in each example. Record this on the chalkboard or chart.

Phenomenon	Observed Effects	Energy Form
burning candle	heat, light	chemical (wax)
moving pinwheel	motion	mechanical (kinetic)
exercising person	heat, motion	chemical (food)
incandescent bulb on	light, heat	electrical
boiling water	heat, motion	heat

3. Discuss the sources of energy for these phenomena, identifying the immediate source, the intermediate source(s), and the primary source. (See next page.)

Evaluation: Review charts done by children. Identify any aspects of the forms and sources of energy that require reteaching.

ENERGY

Phenomenon	Observed Effect	Energy Form	Immediate Source	Intermediate Source(s)	Primary Source
burning candle	heat light	chemical	petroleum		sun
moving pinwheel	motion	mechanical (kinetic)	wind		convection by sun
exercising person	heat motion	chemical	eggs	chicken/chicken feed	sun
			milk	cows/grass	sun
			toast	flour/grains	sun
				milk/cows/grass	sun
				vegetable oil/corn	sun
				yeast/sugar/sugar cane	sun
			grapefruit	grapefruit tree	sun
incandescent bulb on	heat light	electrical	chemical combustion of fuel	animals/plants/green plants	sun
			or water power	lifted water	sun
			or nuclear		sun (fissionable materials

OBJECTIVE 3: *Students will explain energy epochs.*

ACTIVITY 27

Learning: People have used different fuels to produce needed energy throughout history.

Materials: "Energy Epochs" chart, Appendix A-5; "Research Guide" activity sheet, Appendix A-6; encyclopedias.

Teacher Information: This is the first in a series of five activities designed to help students understand the sequence in the development of energy sources. If young people are to understand the ever increasing consumption of oil and natural gas, they need the background provided in these activities.

Procedure: Tell students this story:

> In 1901 Greatgrandma and Greatgrandpa Adler came to California by train. The train engine burned coal to produce the steam that drove it. They settled in San Diego in a large house near 14th and "C" Streets. The house was heated by wood and lighted by oil lamps. Greatgrandma Adler cooked on a wood-burning stove and did the laundry in a big tub on the back porch. She hung the laundry on a line that Greatgrandpa had put up in the back yard. They had a garden that provided most of their fresh vegetables in the summer, and Greatgrandma canned vegetables for winter needs. She put the butter that she churned in an icebox in the kitchen that kept food cool as long as the iceman came regularly and put a large block of ice in it. Greatgrandpa Adler walked to work at 5th and Broadway. It was just over a mile, and he thought nothing of it--the exercise kept him fit. The Adler children walked to school, and on Saturday the entire family walked to synagogue.

Ask students to recall the sources of energy that were mentioned in this story. List them on the board (coal, wood, oil). Point out the absence of gasoline or natural gas. Explain that this story took place in one "energy epoch" and we now live in another. There have been many epochs in the history of energy.

Show the "Energy Epochs" chart and explain that this chart shows our use of fuels from about 1850 to the present with a question for the future. Even though this is only a small portion of time, it shows that we were relying mostly on wood in the mid-1800's and using relatively little. By the turn of the century, we had converted mostly to coal, and the increase in consumption is apparent. By the 1920's oil was being used more and more with natural gas becoming a major source of energy by the early 40's. The first nuclear generating plant was opened in Pennsylvania in 1957 to usher in perhaps another epoch. However, at the present time we are depending primarily on oil and natural gas.

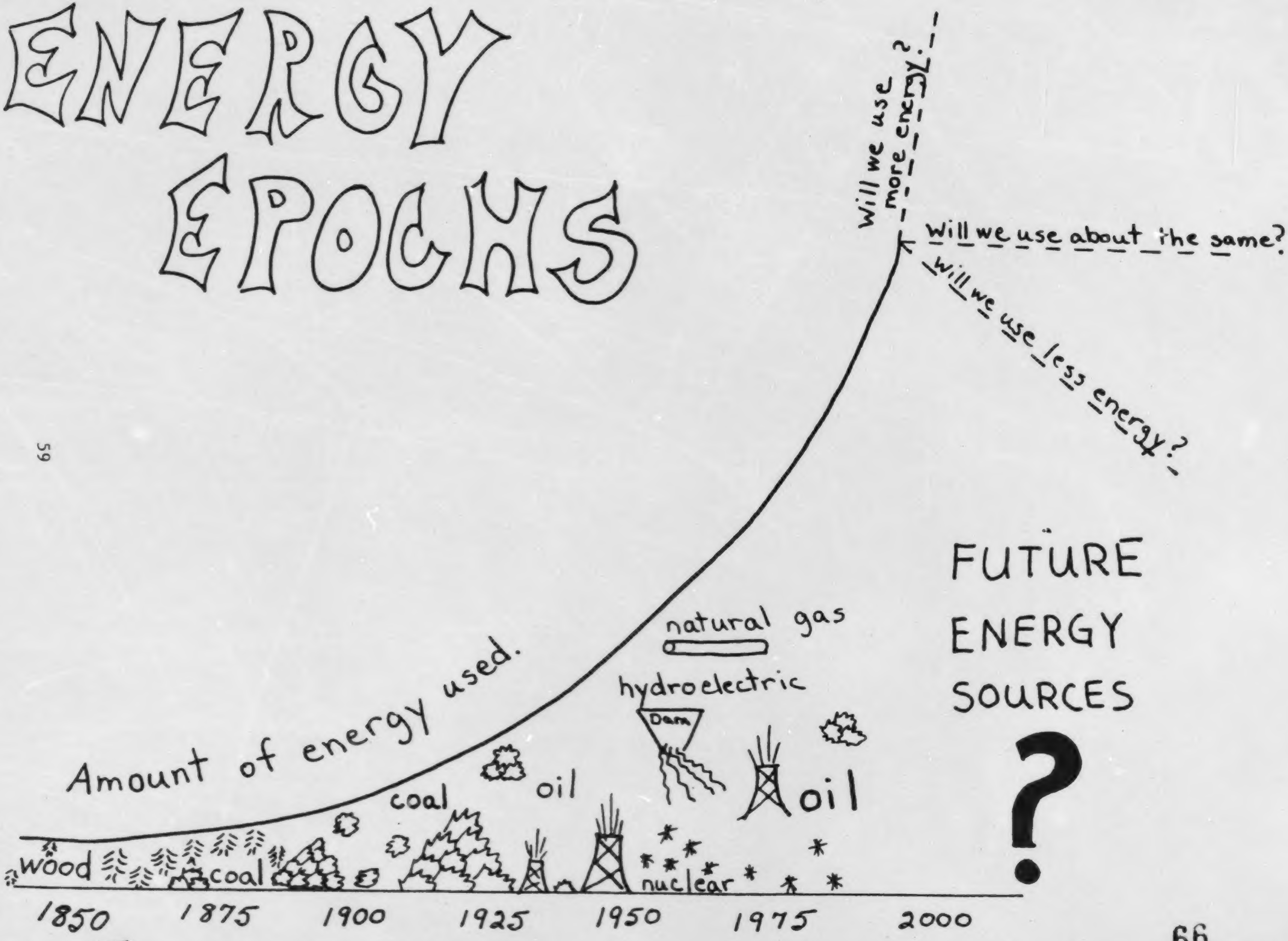
In order to complete the energy epoch chart (before Greatgrandma and Creatgrandpa Adler's time), assign small groups of students one of these as a research project:

Muscle Power (man and animal) as a Source of Energy
Water as a Source of Energy
Wind as a Source of Energy
Steam as a Source of Energy
Coal as a Source of Energy

After each group reports back to the class on their research project, make an Energy Time Line to reflect the many energy epochs in the history of mankind. Illustrate each epoch.

Evaluation: Have students determine the reasons for the transition from one energy epoch to another.

ENERGY EPOCHS



RESEARCH GUIDE

1. Topic for research: ______________________________

2. Use the index of books to find page numbers that will give you information. Write them: ______________________________

3. Read the pages in the first source. Summarize each page.

____
____
____
____
____
____
____
____

4. Repeat for each source.

____
____
____
____
____

5. What is the main idea of what you read? ______________________________
____
____
____

6. If there is a picture or chart that will help explain the information, draw it on a piece of large paper.

7. Think of how you can present your ideas to the class so they will understand what you found.

ACTIVITY 28

Learning: Inventions have opened the door to new epochs in the history of energy.

Materials: Encyclopedias, other classroom resources, "Research Guide" activity sheet (Appendix A-6).

Procedure: Have small groups of students research the following inventions:

Railroad locomotive
Steamboat
Reaper
Telegraph
Automobile
Airplane
Synthetics

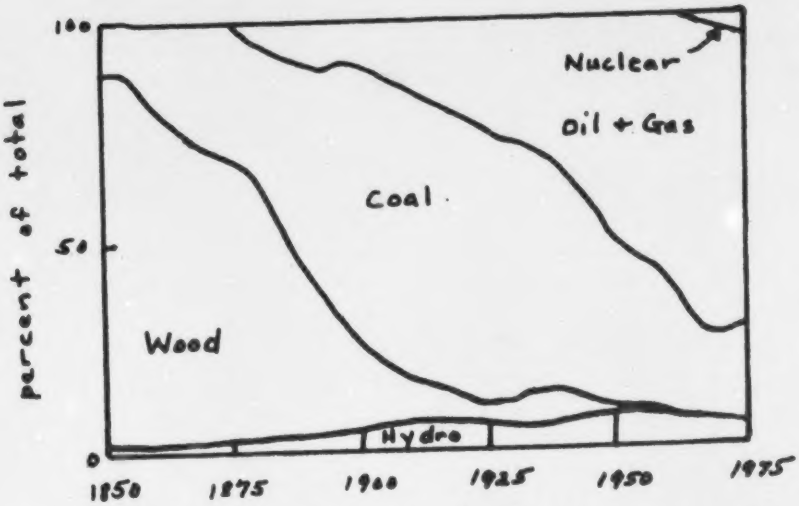
As students report to class, have them indicate the impact of that particular invention on energy consumption.

Evaluation: Determine the position of each invention on the Energy Time Line.

ACTIVITY 29

Learning: Each energy epoch has had advantages and disadvantages.

Procedure:


Historical U.S. Energy Mix

Referring to the energy epoch in which coal was the main energy source, discuss the breakthrough the use of coal was for this country. It provided for many luxuries. It also caused much pollution. Then we moved into the oil epoch. Oil and natural gas are cleaner and easier to use. Why, then, are there problems?

Have students find the meaning of "technology" in the dictionary. Discuss to make sure they understand.

Evaluation: Have students name some advantages of the energy epoch that we are in now. List these on the board under "Advantages." Do the same for "Disadvantages."

Repeat the process for each of the epochs on the Energy Time Line.

EPOCH	ADVANTAGES	DISADVANTAGES
Oil		
Gas		
Coal		
Wood		
Wind		
Water		

Extended Activity: Preprint the name of each energy epoch on a chart or poster. Divide the children into groups to represent each energy epoch, so that approximately the same number are in each group. Have the children discuss within their group the ways in which people used the energy sources available during their assigned epoch.

Have one child at a time draw a picture representing the way people used the energy available to them on the preprinted poster. Let them continue until they run out of ideas or out of space on the poster. Hang the posters up in chronological order. Let children from the prehistoric group state why their source of energy was good. Then have each group, successively, explain why their energy source was better. From this discussion children should gain an understanding of why each succeeding epoch became the viable one.

ACTIVITY 30

Learning: Man has discovered new forms of energy throughout time. These discoveries have influenced methods of transportation.

Materials: Mural paper, yellow chalk, paints, brushes, containers of water.

Teacher Information: Students must have been exposed to the historical development of energy before beginning this project. Discuss with the students the forms of transportation that man used during each of these periods. Also discuss with them forms of transportation that they would invent to use the newer sources of energy. List all of these on the chalkboard.

Procedure: Divide the mural into periods of the development of each energy source. Have students use the chalk to draw the form of transportation used by human beings--from walking and riding on animals to nuclear-powered ships, concluding with their own inventions.

Assign three or four children at a time to paint the mural. Remind them to work from top to bottom and from background to foreground. Give each child an opportunity to do some of the painting. Use the mural to help children understand how our transportation methods are related to the available energy sources.

Evaluation: Have students explain the mural to other classes.

OBJECTIVE 4: *Students will be able to identify several environmental concerns that are energy-related.*

ACTIVITY 31

Learning: Automobiles contribute significantly to the pollution in the air.

Materials: Paper, pencil

Teacher Information: The molecules of petroleum products such as gasoline are long chains of carbon atoms with hydrogen atoms projecting from both sides of the chain. Such a molecule resembles a fish skeleton. The chain of carbon atoms is the backbone, the hydrogen atoms are at the tips of the ribs. Unlike a fish skeleton, it doesn't lie flat, because the hydrogen atoms repel each other, causing ruffles or twists. A few of the carbon atoms have sulfur rather than hydrogen attached.

When a petroleum product is completely and efficiently burned, the carbon and hydrogen combine with oxygen to form carbon dioxide and water, and the sulfur forms a small amount of sulfur dioxide. No one knows how to accomplish complete combustion inside an automobile engine. Therefore, automobile exhaust contains additional substances. As a result of incomplete, inefficient combustion at high temperatures, carbon monoxide is formed, and the nitrogen in the air combines with the oxygen to form nitrogen oxides. Some of the carbon is not burned at all and comes out as soot. Sulfur dioxide is formed, as it would be in any event, along with a tiny amount of sulfur.

Most of the exhaust substances mentioned are gases. Measuring them requires special instruments. Soot and water are easily observable, however. Sulfur would be observable except for the extremely tiny amounts produced.

Procedure: Invite an automobile dealer to the classroom and bring an exhaust emission analyzer.

Have the dealer show which emissions are given off as by-products of incomplete combustion of gasoline.

Have the dealer show on a car how adjustments to the engine directly affect the emissions given off by the car.

Evaluation: Conclude that it is the incomplete combustion of gasoline that contributes to air pollution.

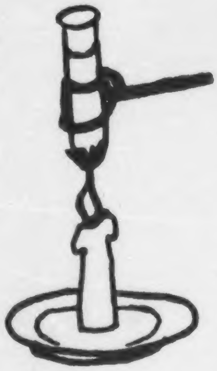
Extended Activity: See Appendix A-7 for a related creative writing project.

ACTIVITY 32

Learning: Energy usage has an effect on the environment.

Materials: Candle, test tube, test tube holder, water

Teacher Information: The use and/or the generation of energy causes pollution in one form or another.



Procedure: Heat water in a test tube over a burning candle. (Chemical energy converted to heat energy--might be used to cook food, create steam to move turbines to produce electricity.) When the water boils, remove the tube from the heat. Hold the test tube up to show the blackened bottom and ask the class what they observe. Ask the class where the soot came from. (Doesn't all *burn*.)

Ask: "In what other situations do we use burning?" (engines--car, truck, ships, trains, planes; furnaces--heating, manufacturing electricity) "Which would you give up for clean air?" Stress how difficult and complicated the choices are. "What would San Diego be like if everyone gave up ________?"

Relate the experiment to smoke stacks of factories or power plants, ships, trains, exhaust from cars, airplanes, etc. Then ask what happens to the soot from these smoke stacks and exhaust systems.

We really need all these things in our life, but we do not like our air being polluted. Ask: "What can we do about it?"

List suggestions on a chart or the chalkboard.

Look at the list and one by one decide whether this idea is one that most people would be willing to accept.

Look at the list again and decide which of the ideas you personally would be willing to accept.

Evaluation: Have students identify energy use that involves burning that would produce carbon waste.

Extended Activity: See Appendix A-7 for an art activity.

ACTIVITY 33

Learning: Transportation of goods from the point of origin to final destination has an environmental impact. Certain types of transportation have less environmental impact than other forms.

Materials: Paper, pencil, fact sheet

Teacher Information: Transportation of freight in our society is a major task. Freight may be transported by trucks, trains, planes, ships. Some suggest that helium balloons be used as freight trains of the future. A current debate among truckers centers around whether or not the 55 mph speed limit is environmentally sound.

Procedure: Look around the classroom. How many of the objects you see were manufactured within this room?

Remember it has taken energy to manufacture and transport them to this room.

The food you ate this morning needed energy to grow and energy to be transported to your home. Some of the foods may also have used energy for cooking or refrigeration.

Our concern today is the impact on our environment by the transportation of goods.

You will be divided into groups so you may work together to work on this problem.

Your job is to list all forms of freight transportation (water, rail, truck, air). For each type of transportation identify and name all of the effects its use has on the environment. Consider the effects of the manufacture of equipment and fuel as well as actual use.

During a class discussion, compile on the chalkboard the thinking of the groups. Have each group identify the most objectionable effect to them.

Evaluation: Conclude that all forms of freight transportation have an environmental impact.

Extended Activity: Give students a copy of "Energy Usage and Approximate Transportation Efficiencies" (Appendix A-8). Discuss the information and its implications.

Energy Efficiency of Alternative Transportation Modes

ENERGY USAGE AND APPROXIMATE TRANSPORTATION EFFICIENCIES: 1973

Passenger Mode	Fuel Usage 1,000 B/D*	Passenger Miles Per Gallon of Fuel
Rail	10	100-500
Bus	70	75-150
Automobile		
Non-Urban	2,000	35
Urban	3,000	25
Air	700	15

Freight Mode	Fuel Usage 1,000 B/D	Freight Ton Miles Per Gallon of Fuel
Water	300	300
Rail	300	180
Truck	1,500	50

*Barrels per day

Sources: Department of Transportation News Release, March 17, 1974;
The Energy Index, 1974, p. 127.

ACTIVITY 34

Learning: The automobile has a harmful impact upon the environment.

Materials: Paper, pencil

Teacher Information: Statistical materials continually show the adverse impact of the automobile upon the environment. Students will be familiar with some of the impacts via TV commercials, etc. Some areas of impact might be materials used in manufacturing the car, sight, smell, hearing, use of land for roads, etc. Have the students develop lists describing at least five ways in which the automobile harms the environment.

Procedure: Say: "Henry Ford is probably the most familiar name among the early developers of automobiles. Since the early 1900's, millions of cars in reds, blues, blacks, and other colors have been manufactured. These vehicles have come in mini sizes clear up to the giant luxury vehicle that has everything including the kitchen sink."

"Automobiles are not distributed evenly throughout the world, country, or even the state of California. Since we live in California, we should be concerned with what happens here as well as throughout the world. California has about one out of every 10 cars registered in the United States."

"With so many cars, we must also have a greater influence (impact) upon the environment. Your job will be to describe at least five ways that cars harm the environment. An example to get you thinking: 'In some cities the noise of the car horns became so loud that laws were passed making it illegal to honk the horn unless an emergency existed. In that case, the sound of the car was harmful.'"

"I'm sure you can find other, better examples of how the car can be harmful to the environment."

Evaluation: Discuss with the class their lists. Suggest that as a class further information might be obtained from the list of agencies in the appendix. Which of the lists have references to the energy used to build the highways; manufacture the automobiles; obtain the ores, plastics, etc.; transport the parts and the fuel for the finished vehicle? Point out that these, too, are considerations of environmental impact.

ACTIVITY 35

Learning: Automobile size determines gasoline use and potential pollution problem.

Materials: Pencils, paper, busy intersection, parking lot, "Traffic Chart" (Appendix A-9), "Your Dream Machine" (Appendix A-10), "Getting There" (Appendix A-11)

Teacher Information: One primary cause of pollution locally is the automobile with its internal combustion engine. All gasoline engines emit various oxides that generate what is known as smog. As a general rule, the larger the car, the larger the engine, the greater the emission into the air.

Procedure: Ask children to think of some ways that pollution from automobiles could be reduced (smaller cars, car-pooling, buses or other rapid transit systems). List the ideas on the chalkboard.

Conduct a survey of neighborhood traffic. Select several busy intersections and keep a record of vehicle type and passenger patterns at different times of day.

Evaluation: Using the chart "Your Dream Machine" and information collected, have students state their observation about the vehicle choice in this neighborhood.

Extended Activity: Save a copy of these records for next year's class to compare with their findings.

TRAFFIC CHART

Date/Time	Cars with Excessive, Noticeable Smoke	Compact Cars	Large Cars	Vans and Trucks	Recreational Vehicles	Three or more Occupants

YOUR DREAM MACHINE

Model	Manufacturer	MPG*
Chevette	GM-Chevrolet	36
Civic CVCC	Honda	44
Corolla Sedan	Toyota	32
Datsun B-210	Nissan	42
Datsun 200SX	Nissan	26
Accord CVCC	Honda	42
Celica GT	Toyota	26
Rabbit	Volkswagen	34
Fiat 128	Fiat	27
VW Station Wagon	Volkswagen	28
Opel (Isuzu)	Isuzu	27
Vega	GM-Chevrolet	28
Dodge Colt	Mitsubishi	35
Pinto	Ford	30
Mazda GLC	Toyo Kogyo	38
Mustang II	Ford	26
Datsun 280Z	Nissan	21
Volvo 244	Volvo	22
Gremlin	American Motors	23
Maverick	Ford	24
Volare	Chrysler-Plymouth	20
Nova	GM-Chevrolet	22
LTD II	Ford	17
GTO	GM-Pontiac	17
Trans Am	GM-Pontiac	17
Matador	American Motors	15
Cutlass Supreme	GM-Oldsmobile	18
Cougar	Ford	16
Ford	Ford	15
Buick Electra 225	GM-Buick	18
Plymouth	Chrysler-Plymouth	15
Silver Shadow	Rolls Royce	12
Chrysler	Chrysler-Plymouth	13
Bonneville	GM-Pontiac	17
Eldorado	GM-Cadillac	14
Buick Wagon	GM-Buick	18
Ford Wagon	Ford	13
Chrysler Wagon	Chrysler-Plymouth	12
Continental Mark V	Ford	13
Toronado	GM-Oldsmobile	15
Grand Prix	GM-Pontiac	17
Thunderbird	Ford	17
Mercedes 280 SE	Daimler-Benz	16
Seville	GM-Cadillac	16
Chevy Van V-8	GM-Chevrolet	18
Dodge Van V-8	Chrysler-Dodge	16
Ford Van V-8	Ford	16
VW Bus	Volkswagen	23

*January 1977 Gas Mileage from EPA City/Highway Test Cycle.

Source: "1977 Gas Mileage Guide for New Car Buyers," U.S. Environmental Protection Agency, January 1977 (Second Edition) Fuel Economy, Pueblo, Colorado 8109 -- Single Copies; Fuel Economy, FEA, DPM Room 6500, Washington, D.C. 20461 -- Bulk Copies.

Name ______________________ Date ________________ Period ______

GETTING THERE

Table 1

Types of Urban Transportation	Fuel Mileage (Average) (MPG = Miles per Gallon)
Automobile	18 mpg
Van	16 mpg
Bus	3.3 mpg
Commuter train	.1 mpg
DC jet	.25 mpg

Table 2

Form of Transportation	Number of People	MPG	Fuel Needed for 20 Mile Trip (In Gallons)	Fuel per Person (PMPG)
Car	1	18	1.11	1.11
Car	2	18	1.11	.56
Car	4	18	1.11	.28
Van	1	16	1.25	1.25
Van	2	16	1.25	.630
Van	8	16	1.25	.165
Bus	5	3.3	6.1	1.2
Bus	20	3.3	6.1	.31
Bus	40	3.3	6.1	.15
Train	1,000	.1	200	.20
Airplane	100	.25	80	.80

Remember: Passenger miles per gallon is arrived at by dividing the number of people into the amount of fuel used.

ACTIVITY 36

Learning: Sulfur dioxide which is given off in burning fossil fuels can cause fabric deterioration.

Materials: Slide frames or suitable stiff cardboard mounts; old, clean nylon stocking material; magnifying glasses or microscopes.

Teacher Information: Sulfur dioxide is a common pollutant in the air. By weight sulfur dioxide constitutes about 2% of the pollutants found in the air. Its source is the burning of fossil fuels. It irritates your eyes, nose, and throat. It reacts with water and other chemicals in the air and has slowly damaged stone statues and buildings, especially in eastern U.S. cities and Europe.

Procedure: Nylon deteriorates with its exposure to sulfur dioxide (SO_2). Attach the nylon stocking material inside the frame. Examine the stocking material under the microscope or magnifying glasses. Place all but one sample outside in different locations. Some should be in areas of shade, others in areas of sunlight. (Keep one inside as a control.) Place the slide mounts in widely differing areas.

After one week bring the samples in for careful examination under magnification. Record the results and put the frames back out for further collection.

Continue checking and recording what is observed. Be sure the frames go back to the same spot.

Evaluation: Have students write an inference, based on their observation records, indicating which locations resulted in the greatest deterioration.

ACTIVITY 37

Learning: Excess heat is produced in energy *transfers*. When this causes an undesirable increase in the temperature of the environment it is called *thermal pollution*. Students will become aware of thermal pollution as an environmental concern.

Materials: Paper, pencils, two glass containers for water, aquarium heater, water from lake, river, or ocean

Teacher Information: All power plants give off unusable heat, whether they use coal, oil, gas, geothermal, or nuclear. This is equally true of auto engines, jet engines, and the human body. The heat rejected from power plants may be beneficial, harmless, or harmful depending on how it is used or released to the environment. Power plants need an enormous amount of cooling water. Nuclear plants need even more water to cool reactors. These plants must be located next to lakes, rivers, or oceans. In the past, too much hot water flowing into a lake or river has caused significant problems. Fish kills and algae growth are two of these problems. The thermal impact of power plants located on oceans is less severe. Federal laws now regulate the temperature of the discharge water. Scientists are finding ways to use this rejected heat for useful purposes.

Procedure: Review basic information and definition of thermal pollution (hot water pollution).

Have students look at water (from pond, lake, river, or ocean) in container A and record observations about the water's appearance. How clear, what color, what temperature, how much algae or plant life in water. (Control)

Pour some of the water sample into a second container (B) and label (experimental). Observe and record changes.

Use heater to raise temperature of experimental water in container B. Have students make daily recordings of any changes in the water.

Evaluation: More heat usually creates more algae growth. It may also stimulate other plant and animal growth.

Discuss ways in which we could use rejected hot water. Discuss what might happen if there were no regulations on hot water pollution.

ACTIVITY 38

Learning: A variety of energy sources are available, but each has an environmental cost. Some sources are very limited.

Materials: Fact sheets and diagrams.

Teacher Information: It is important to be aware of the major sources of energy and how they may be used. Included in the guide are fact sheets giving you and the students current information about each source. We all are aware that our fossil fuels (coal, oil, natural gas) are being used up and are not being replenished. Like the bank account with no deposits, any time we withdraw fuel from our bank reserve, the amount left is depleted. The reserves left in fossil fuels are limited. The amount of energy used in the United States continues to rise. Conservation of energy use and resources will help delay the exhaustion of our fossil fuels. During the limited time left it is important to examine all available energy sources. From a practical matter, some of the sources listed have limited markets until further technology is developed to expand their use. Nuclear fission as a source of energy has been used for several years. Its proponents illustrate it as relatively efficient in terms of land use (compared to strip mining, terrestrial solar arrays, etc.), cost, safety and environmental impact. The opponents of nuclear power make references to the nuclear bombs dropped on Japan, the thermal pollution associated with nuclear plants (or any plant where large conversions of energy must take place), the radioactive wastes with tremendously long half-lives and with the danger of melt-down and its radiation dangers. It may be safely stated that opponents and proponents of nuclear power will continue to debate the issue for many years.

Nuclear fusion, the combining of nuclei to produce energy, is in its theoretical stages. Current projections show commercial availability of fusion to begin near 2010. Some feel fusion to be much safer environmentally than fission. Research and development teams worldwide are working on developing fusion as a practical alternative to our current sources of energy.

The other sources of energy listed through an advancing technology call all to assist in the reduced use of the nonrenewable resources. In the areas of the southwestern United States, solar energy for space heating and photovoltaics (conversion of sunlight to electricity) may assist reducing the use of natural gas, etc., for these same purposes.

Procedure: Distribute the fact sheets and diagrams to the students.

Read the sheets and discuss them in the class or in small groups.

Have the students retain the sheets for reference during subsequent discussions of energy sources.

Evaluation: The students should be able to answer the following questions:

"What are the major energy sources?"
"What is the availability of the source?"
"What are the prospects for future use?"
"What problems are associated with the sources?"

OBJECTIVE 5: *Students will be able to give examples of activities that involve an energy cost as well as an economic cost.*

ACTIVITY 39

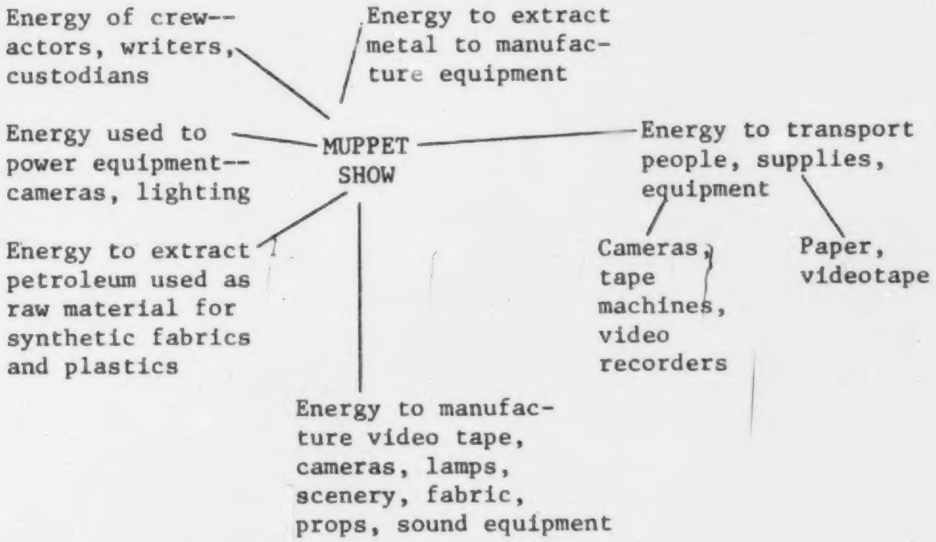
Learning: Products and services include an energy cost as well as an economic cost.

Materials: Chalk and chalkboard, paper and pencil

Teacher Information: In order to heighten your students' awareness of energy use, stress listing of specific details about the product or service, i.e. name the equipment involved.

Procedure: Say: "When we think of goods and services and what they cost, we usually think of a monetary price tag. Today, let's look at the energy cost."

Select a product or service and, with the class, record details of the energy cost involved. Consider equipment, supplies, power, raw materials, manufacturing processes and transportation. For example:


MUPPET SHOW
Energy of crew--actors, writers, custodians
Energy to extract metal to manufacture equipment
Energy used to power equipment--cameras, lighting
Energy to transport people, supplies, equipment
Cameras, tape machines, video recorders
Paper, videotape
Energy to extract petroleum used as raw material for synthetic fabrics and plastics
Energy to manufacture video tape, cameras, lamps, scenery, fabric, props, sound equipment

Assign individuals or groups to prepare a diagram of their own, using a different service or product.

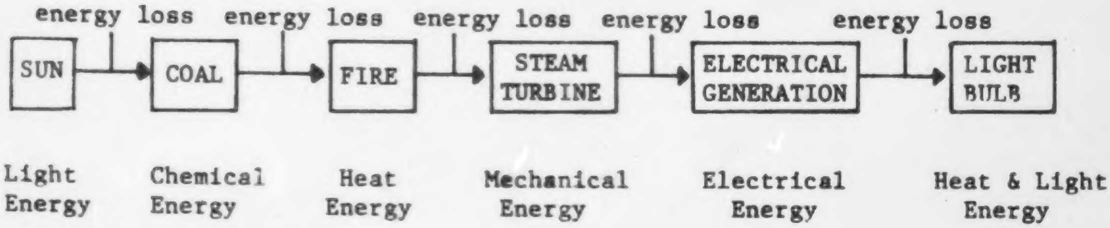
Evaluation: Given a product, students can identify energy costs associated with that product.

ACTIVITY 40

Learning: Consumption of energy has a direct and indirect cost.

Procedure: Using the following diagram, explain to students that there are two basic ideas about energy that are important in understanding the direct and indirect costs of energy consumption.

1. Energy is not really consumed but only changed in form. For example, energy could flow through the system diagrammed below:


energy loss
energy loss
energy loss
energy loss
energy loss
SUN
COAL
FIRE
STEAM TURBINE
ELECTRICAL GENERATION
LIGHT BULB
Light Energy
Chemical Energy
Heat Energy
Mechanical Energy
Electrical Energy
Heat & Light Energy

2. When energy is converted from one form to another as shown above, *not all* the energy is changed to the new form. *Some is lost or wasted.* The more conversions between the primary source of energy and the final use of the energy, the greater the energy waste. *Energy cannot be recycled.* Once lost, energy cannot be recovered or reused.

Have students independently diagram the energy flow from the sun to a person traveling on a bicycle. Label points of energy loss and identify the forms of energy.

Have students explain their diagrams to the class, identifying how they think energy is lost or wasted at each transfer.

Evaluation: Conclude that in energy use involving transfer of energy there is also the indirect energy cost of energy lost but not applied to the task.

ACTIVITY 41

Learning: Fossil fuels which can easily be converted into energy may also have higher and better uses.

Materials: Pictures of products made with petrochemicals: paint, fertilizers, detergents, tires, cosmetics, plastics (lenses, furniture, toys, equipment, packaging, and containers), synthetic fabrics, and dyes; pictures of fuel-burning transportation, fuel-burning stoves, furnaces and lanterns.

Teacher Information: Petroleum is a nonrenewable resource which we use in a multitude of ways. Choices about these uses should be conscious.

Petrochemicals are chemicals obtained from the refinement of crude oil. These petrochemicals form the basis for thousands of products which include plastics, man-made fibers, synthetic rubber, detergents, medicines, cosmetics and solvents. Many of the chemicals may also be obtained from coal, coke, and other vegetable products.

Petroleum is also used as an energy source to power transportation, manufacturing, and supply heat and light.

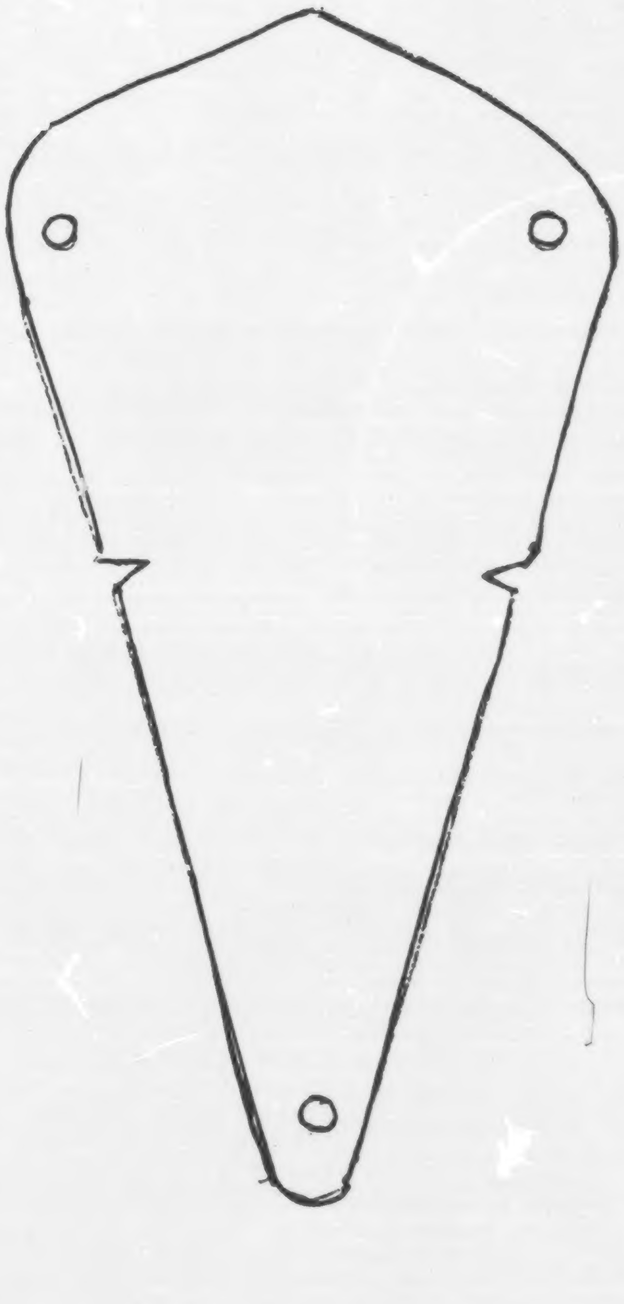
Procedure: Share the teacher information with the class. Ask students to identify and list examples of petrochemicals or fuel use in their lives.

Discuss with students the idea that the real cost of anything is what you give up to get it.

Remembering that petroleum is a non-renewable resource, ask students to identify from the class list three uses of petroleum which they consider essential and three which they consider nonessential.

Evaluation: Conclude that thoughtful choices need to be made about use of petroleum as an energy supply or as the raw material for products.

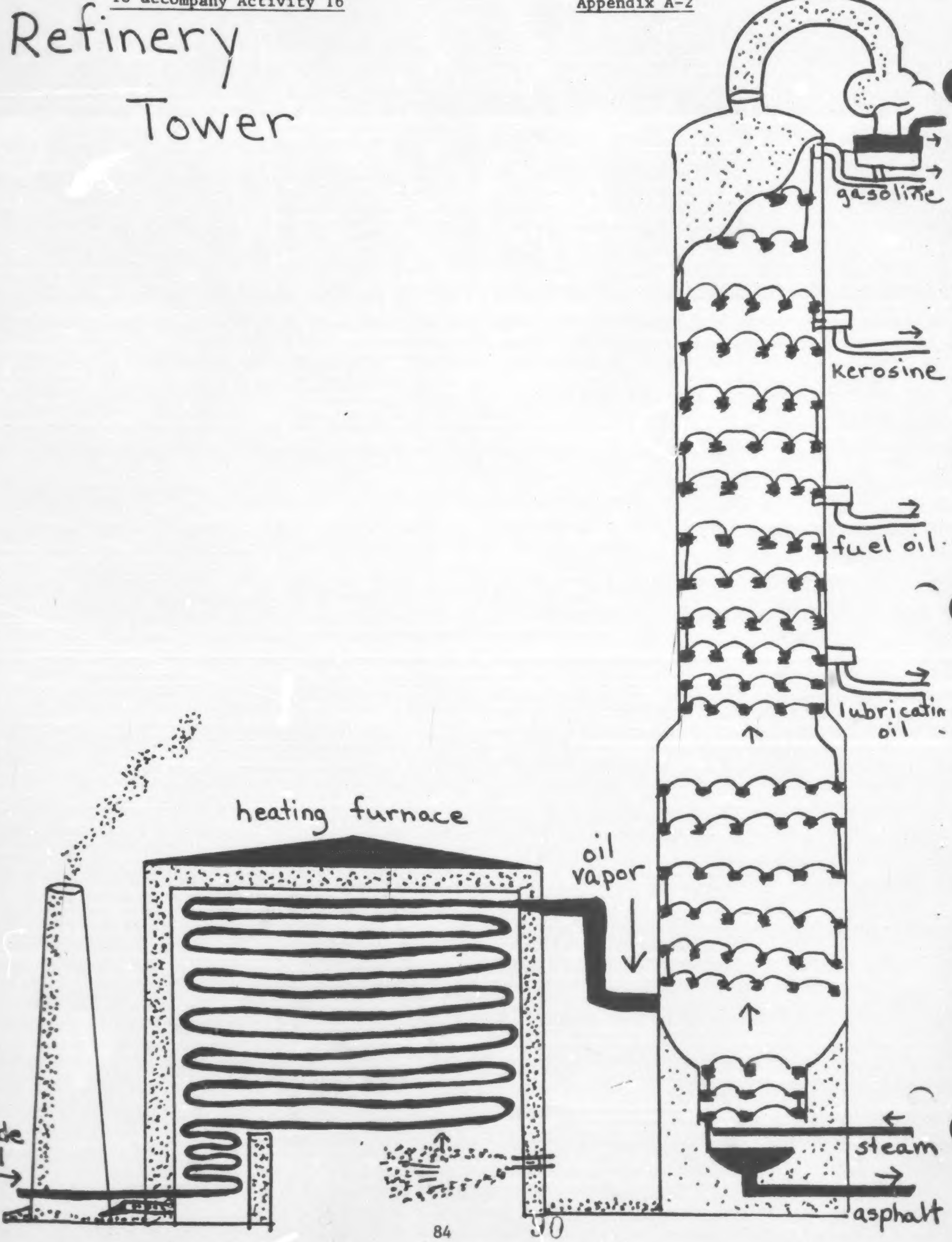
APPENDICES



To accompany Activity 16

Appendix A-2

Refinery Tower


gasoline
kerosine
fuel oil
lubricatin
oil
heating furnace
oil
vapor
rude
oil
steam
asphalt

Name ______________________________ Date ____________________

ENERGY CONVERSION

Energy is often converted from one form to another, either naturally or through the efforts of people.

Identify examples of energy conversion from each of the energy forms on the following charts:

MECHANICAL ENERGY		
Situation	Observation	New Energy Form

ELECTRICAL ENERGY		
Situation	Observation	New Energy Form

91

<table>
<tr><th colspan="3">CHEMICAL ENERGY</th></tr>
<tr><th>Situation</th><th>Observation</th><th>New Energy Form</th></tr>
<tr><td></td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="3">LIGHT ENERGY</th></tr>
<tr><th>Situation</th><th>Observation</th><th>New Energy Form</th></tr>
<tr><td></td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="3">HEAT ENERGY</th></tr>
<tr><th>Situation</th><th>Observation</th><th>New Energy Form</th></tr>
<tr><td></td><td></td><td></td></tr>
</table>

To accompany Activity 26

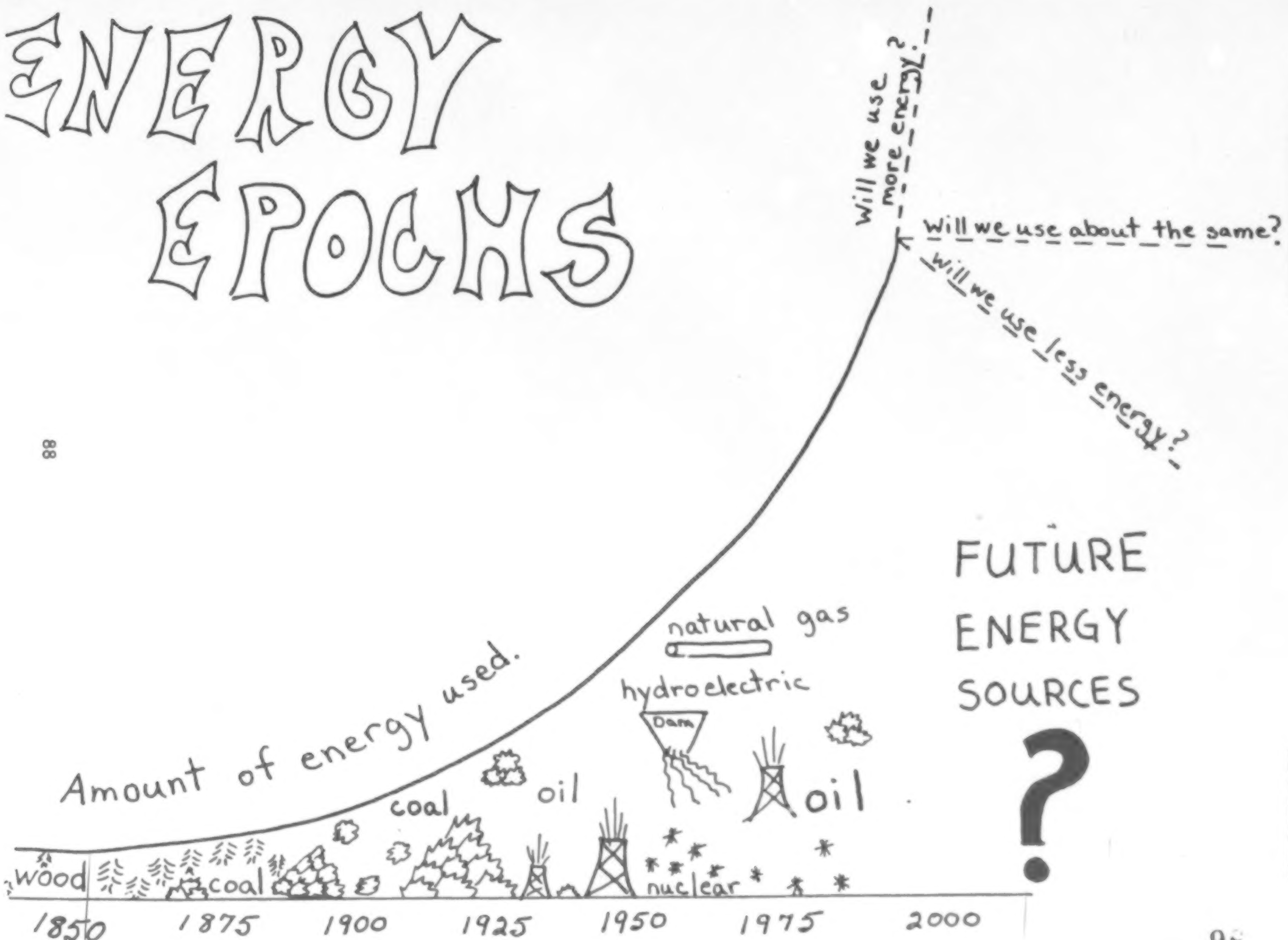
ENERGY

Phenomenon	Observed Effect	Energy Form	Immediate Source	Intermediate Source(s)	Primary Source

Appendix A-4

To accompany Activity 27

ENERGY EPOCHS



Appendix A-5

RESEARCH GUIDE

1. Topic for research: ______________________

2. Use the index of books to find page numbers that will give you information. Write them:

   ____

3. Read the pages in the first source. Summarize each page.

   ____

   ____

   ____

   ____

   ____

   ____

   ____

   ____

4. Repeat for each source.

   ____

   ____

   ____

   ____

   ____

5. What is the main idea of what you read? ______________________

   ____

   ____

   ____

6. If there is a picture or chart that will help explain the information, draw it on a piece of large paper.

7. Think of how you can present your ideas to the class so they will understand what you found.

Appendix A-7

Learning: Air pollution is an environmental concern caused by the use of energy.

Materials: Crayons, 12" x 18" manila, writing paper, pencils

Procedure: This is the scenario: "Your name is Gotta Gearloose. You are a scientist and inventor who lives in the town of Fairview. Many citizens in your town have complained to the mayor that the air in Fairview is not as clean as it used to be. Because he is running for reelection, the mayor, Mr. Win D. Bag, has decided to do something about the problem immediately (if not sooner!). He has decided to *ban* all automobiles as a form of transportation. He has asked you, Gotta Gearloose (world-famous inventor), to design a new form of transportation that will not pollute the air. Your plan is due at the end of this period. (This is a rush order--election is next week!)"

Ask:

1. What kind of energy will your new form of transportation use?
2. Will it go on land, in the air, on water, or underground?
3. How many people will it carry?
4. How big will it be (size-wise)?
5. What will it look like?
6. How fast will it go?
7. How safe is it?
8. How often will it need to be repaired?

Evaluation: Instruct students to draw a picture of their new pollution-free forms of transportation and write a paragraph describing it.

To accompany Activity 33

Appendix A-8

Energy Efficiency of Alternative Transportation Modes

ENERGY USAGE AND APPROXIMATE TRANSPORTATION EFFICIENCIES: 1973

Passenger Mode	Fuel Usage 1,000 B/D*	Passenger Miles Per Gallon of Fuel
Rail	10	100-500
Bus	70	75-150
Automobile		
Non-Urban	2,000	35
Urban	3,000	25
Air	700	15

Freight Mode	Fuel Usage 1,000 B/D	Freight Ton Miles Per Gallon of Fuel
Water	300	300
Rail	300	180
Truck	1,500	50

*Barrels per day

Sources: Department of Transportation News Release, March 17, 1974; The Energy Index, 1974, p. 127.

TRAFFIC CHART

Date/Time	Cars with Excessive, Noticeable Smoke	Compact Cars	Large Cars	Vans and Trucks	Recreational Vehicles	Three or more Occupants

To accompany Activity 35 Appendix A-10

YOUR DREAM MACHINE

Model	Manufacturer	MPG*
Chevette	GM-Chevrolet	36
Civic CVCC	Honda	44
Corolla Sedan	Toyota	32
Datsun B-210	Nissan	42
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Grand Prix	GM-Pontiac	17
Thunderbird	Ford	17
Mercedes 280 SE	Daimler-Benz	16
Seville	GM-Cadillac	16
Chevy Van V-8	GM-Chevrolet	18
Dodge Van V-8	Chrysler-Dodge	16
Ford Van V-8	Ford	16
VW Bus	Volkswagen	23

*January 1977 Gas Mileage from EPA City/Highway Test Cycle.
Source: "1977 Gas Mileage Guide for New Car Buyers," U.S. Environmental Protection Agency, January 1977 (Second Edition) Fuel Economy, Pueblo, Colorado 8109 -- Single Copies; Fuel Economy, FEA, DPM Room 6500, Washington, D.C. 20461 -- Bulk Copies.

Name ________________________ Date ______________ Period _______

GETTING THERE

Table 1

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Bus	20	3.3	6.1	.31
Bus	40	3.3	6.1	.15
Train	1,000	.1	200	.20
Airplane	100	.25	80	.80

Remember: Passenger miles per gallon is arrived at by dividing the number of people into the amount of fuel used.

SAN DIEGO CITY/COUNTY SCHOOLS ENERGY EDUCATION COMMITTEE
6401 Linda Vista Road, San Diego, Ca 92111 (714) 292-3641

Ms Judith Adams
Coordinator Science Office
KPBS TV
Dr Robert A Dean
Curriculum Coordinator
Science
Department of Education
Dr M Ted Dixon
Superintendent of Schools
Department of Education
Ms Molly Jean Featheringill
Executive Director
San Diego Ecology Centre
Mr Douglas M Fouquet
Coordinator, Community Relations
General Atomic Company
Mr Clifford T Fredrickson
Science Specialist
San Diego City Schools
Dr Thomas L Goodman
Superintendent of Schools
Secretary, Board of Education
San Diego City Schools
Mr John E Hamrick
Vice President Marketing
San Diego Gas & Electric Company
Dr Roy E Harris
Social Studies Specialist
San Diego City Schools
Mr Otto A Hirr
Assistant to the President
San Diego Gas & Electric Company
Mr Archie P Kelley
San Diego Representative
ERDA
Mr Edward Kimura
Sierra Club
Mr Nicholas R King
Curriculum Resource Teacher
San Diego City Schools
Dr Jeffrey W Kirsch
Director Science Office
KPBS TV
Mrs Jimmie L Martinez
Consultant Elementary Social Studies
San Diego City Schools
Ms Gail P MacLaughlin
Assistant Director Public Relations
San Diego Gas & Electric Company
Mrs Melanie Messer
Consultant to the
Department of Education
Mr Robert R Miller
Energy Administrator
Rohr Industries
Mr Robert E Morris
President
San Diego Gas & Electric
Dr Edward J Neuner
Professor Economics
San Diego State University
Mr William H Pettus
Energy Management Coordinator
University of California, San Diego
Mr. Ernest J. Robe on
Public Relations Supervisor
San Diego Gas & Electric Company
Mr Rudolph J Schafer
Consultant Conservation Education
State Department of Education
Dr Gilbert E Stuvé
Curriculum Coordinator
Social Science
Department of Education
Mr John Sullivan
Curriculum Resource Teacher
Elementary Science
San Diego City Schools
Mr Philip Vermeulen
Conservation Division
California State Energy Commission

Mr. John K. Gessel
Committee Coordinator
Director, School—Community Services
Department of Education

MARCH 1977

GOALS AND OBJECTIVES FOR ENERGY EDUCATION IN SAN DIEGO COUNTY

All students attending the primary, elementary, and secondary schools in San Diego City and County need to know that modern civilization is dependent upon vast amounts of energy to drive the wheels of industry, agriculture, transportation, and to provide people with warmth to protect their health and welfare.

Because the flow of energy into and within the United States is under jeopardy, the San Diego City/County Schools Energy Education Committee was formed in the spring of 1975 to bring to teachers' attention the problems our country is confronted with concerning energy supply and demand.

The committee is dedicated to motivating teachers to help their students learn there are challenges ahead of them to overcome these energy problems. In order to help this process, the committee has developed this set of energy education goals and objectives as its guideline for developing conferences, curriculum materials, and inservice workshops.

The goals and objectives are divided into two parts. Part I contains three program goals which are background for, and in support of, the five student goals which make up Part II of the document. The program goals are stated without accompanying objectives, but the student goals do have objectives that delineate what learners should accommodate and assimilate as part of their body of knowledge.

There are two ideas that permeate the goals and objectives: first, the concept that energy and environment are interwoven is expressed as "energy/environment," and second, as these goals and objectives are implemented, as many local examples as possible will be used to illustrate the objectives.

1977 Theme: "Energy Futures - What's Ahead?"
1975 Theme: "Energy - Environment - Economics" 1976 Theme: "Energy Conservation"

PROGRAM GOALS

Goal Number 1:

A Balanced Energy/Environment Education Program Will Be Developed

The entire spectrum of pro and contra arguments for individual issues needs to be presented so that the student who become future decision makers are making judgments based upon a complete and not a partial picture of the problem; these students must have adequate information on all aspects of the situation, and should be helped to develop the skills and techniques of information analysis and decision-making. Programs that are developed for the public schools will be reviewed by a subcommittee of the San Diego City/County Schools Energy Education Committee.

Goal Number 2:

An Historical Background of the Energy Problem for Teachers Is Needed

Teachers should understand what energy is, where it comes from, and how its form is changed; that there have been several transitions from one major form of energy utilization to another during the history of man; that we are now living through such a transition; that the transitions have been accompanied by technological developments which may provide an insight on how the present problems can be overcome.

Goal Number 3:

An Array of Educational Delivery Systems Must Be Maintained

Materials, both printed and audio-visual, must be produced, and whatever is published must be properly introduced to teachers through inservice programs about how to use the materials with their students; speakers' bureaus, conferences, workshops, clearinghouses, television, mass media, industrial tours, and semester courses all must be used to disseminate information.

STUDENT GOALS AND OBJECTIVES

Goal Number 1:

Identifying Past, Present, and Alternative Sources of Energy

More than identifying the sources, students should understand what energy is and that workable solutions may come from new, more efficient methods of converting known sources of energy into usable forms of energy and what the trade-offs are for utilizing each of the various energy forms.

Objectives:

1. Students will gain a basic, simplified understanding of technology as it relates to energy.
    - a. Define *energy, work, power, force, heat, fuel, combustion, fission, fusion, photoelectricity.*
    - b. Know the laws of thermodynamics and recognize the fallacy of perpetual motion machines.
    - c. Know commonly used units such as *BTU, kilowatt, kilowatt hour, horsepower, therm, ton, barrel,* etc.
2. Students will gain an historical perspective on alternative sources of energy.
    - a. Transition from one energy epoch to another.
    - b. Reasons why the next epoch became the viable one.
    - c. Identify where each major society presently is on the energy epoch spectrum in terms of how much they consume and produce, and how that affects their lifestyles.
    - d. Outline the choices for bridging this particular transition.
3. Students will be aware of present alternative sources of energy and the consequences of each.
    - a. Types of energy sources; energy mix of the United States and the world.
    - b. Cost/efficiency of energy conversion of end uses.
    - c. Renewable vs. nonrenewable sources.
    - d. Environmental concerns.

4. Students will be aware of future alternative sources of energy and the consequences of each.

    a. Types of energy sources.

    b. Cost/efficiency of energy conversion to end uses.

    c. Renewable vs. nonrenewable sources.

    d. Environmental concerns.

    e. Encouragement for developing new processes and products.

    f. Knowing about career opportunities.

Goal Number 2:

Conservation of Energy is an Important Immediate Necessity

To help our nation more effectively utilize its limited energy resources, we will have to resort to several forms of conservation including turning off lights, insulating buildings, driving more efficient cars, and many other methods; some will be voluntary and others will be mandatory; conservation should be viewed as another "source" of energy in the sense that energy which was previously wasted can be productively used to meet needs elsewhere in the economy.

Objectives:

1. Students will know the ways they (personally) use energy.

    a. Direct uses.

    b. Indirect uses.

2. Students will know the various ways their society and industry utilize energy.

3. Students will make an analysis of energy uses regarding how much energy is received as compared to the amount needed to produce it.

4. Students will know conservation techniques, including the energy efficiency techniques and how they are applied in homes and industry.

5. Students will understand the consequences of their choices and decisions upon energy problems.

    a. Voluntary.

    b. Mandatory--pricing, rationing.

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6. Students will learn that conservation is an alternate energy source.
    a. Historically, resources were treated as unlimited.
    b. Energy conservation is a recent concept that can yield benefits for our society.
    c. Realization that energy resources are limited (therefore, the need for conservation).
    d. Rededication to the conservation ethic.

Goal Number 3:

Understanding the Economics of Energy/Environment Utilization

The economics theme will impinge upon each of the other themes - everything has a cost - and it is important for students to know what these financial and environmental costs are.

Objectives:

1. Students will know the economic perspectives of energy costs.
    a. Every activity involves an energy cost as well as an economic cost.
    b. The real cost of anything is what you give up to get it.
2. Students will know how the individual relates to the economic system in determining energy costs.
    a. Consumption involves both direct and indirect uses of energy and costs.
    b. Production involves both direct and indirect uses of energy and costs.
        (1) Comparison of end-use efficiency costs.
        (2) Conversion of energy vs. additional capital costs.
        (3) Funds spent on research and development may make new sources of energy competitive with current sources of energy.
3. Students will know how pricing influences energy costs.
    a. The laws of supply and demand in an open market.
    b. The laws of supply and demand in a regulated market.
4. Students will learn how political and economic decisions are intertwined.

Goal Number 4:

Understanding the Political Aspects of the Energy/Environment Problem

Whether the international, national, or local political window is being viewed, students need to know how foreign nations, along with national and local political leaders influence the solutions to broad-based problems of this nature.

Objectives:

1. Students will determine their individual household energy policies.
2. Students will understand the need for a national energy policy.
3. Students will understand what the existing local, state, regional, national, and international policies are, and know they are constantly changing.
4. Students will understand how and why policies are formulated.
5. Students will understand how individuals affect household, local, state, regional, national, and international policy.
6. Students will understand how groups affect household, local, state, regional, national, and international policy.
    a. Consumers
    b. Conservation
    c. Labor
    d. Business
    e. Cartels
    f. Trade organizations
    g. Regulatory bodies
7. Students will perform a critique of existing energy policies to determine their effectiveness.
8. Students will be able to analyze information to determine bias as a means of making informed political decisions.

Goal Number 5:

Learning About the Social Aspects of the Energy/Environment Problem

For the energy problem to be meaningful, it must be felt on the home and neighborhood level. It is at this level that most people will be able to help ameliorate some of the energy problems. After that, people will then be more able to contribute to solving some of the larger social aspects associated with the energy problem.

Objectives:

1. Students will understand relationship between spending patterns and social level.
2. Students will become aware of cultural patterns (Amish, poor, affluent, other countries, etc.).
3. Students will understand social responsibility for energy consumption.
4. Students will understand how energy costs and energy policies affect different social groups to different degrees.
5. Students will understand the effect of limited natural resources upon different social groups.
6. Students will become aware of the effect of limited natural resources upon lifestyles.
7. Students will understand how energy costs cause social disruptions.
8. Students will understand how to analyze information to determine social and environmental effects that result from various energy policies.
9. Students will gain ability to analyze information to determine credibility of energy concerns.
10. Students will analyze willingness (of society) to try new solutions to overcome energy problems.

FACT SHEETS*

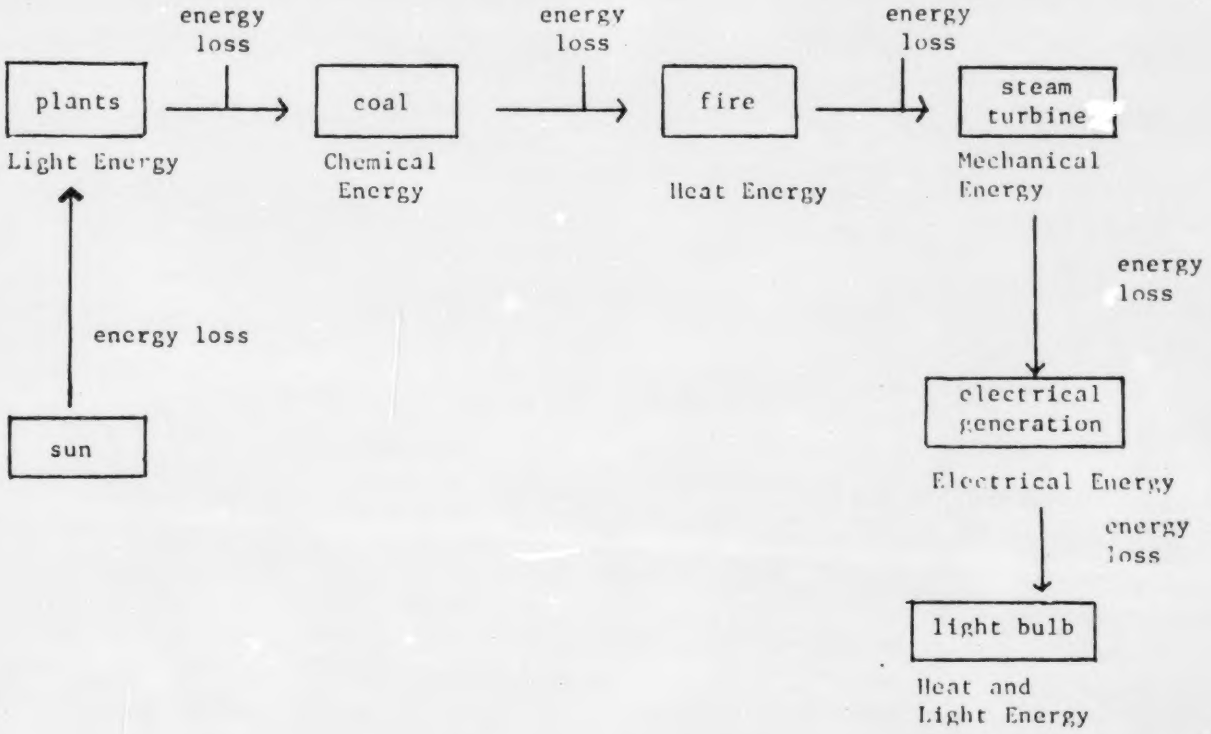
Introduction

What is Energy?

Energy equals the capacity to do work, and power is the rate at which work is done. The work it does allows the biosphere to operate and allows us to maintain our agricultural and industrial civilization. Radiant energy flowing from the sun warms the earth to temperatures which sustain life, drives the hydrological cycle of evaporation and precipitation, powers the winds and ocean currents, and is captured by the green plant which is the food base for most living things. The plant was also the starting point of fossil fuels.

Two ideas about energy are important in understanding energy problems:

1. Energy is not really consumed, but only changed in form. For example, energy could flow through the system diagrammed below:


energy loss
energy loss
energy loss
plants
coal
fire
steam turbine
Light Energy
Chemical Energy
Heat Energy
Mechanical Energy
energy loss
energy loss
sun
electrical generation
Electrical Energy
energy loss
light bulb
Heat and Light Energy

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*Taken from Energy for Today and Tomorrow, a San Diego City/County Schools Publication.

2. When energy is converted from one form to another as shown above, not all the energy is changed to the new form - some is lost or wasted.

The more conversions between the primary source of energy and the final use of energy, the greater the energy waste.

This wasted energy cannot be recycled. Since it can no longer be put to productive use, it is lost.

The primary energy sources are solar, hydro, coal, wind, petroleum and natural gas, nuclear and geothermal.

Energy in San Diego

According to R. R. Higgins, Economist with San Diego Gas and Electric Company, ".... There are no commercially developed natural fuel resources in the county of the types which could be used by San Diego Gas and Electric Company. Over the years there have been unsuccessful explorations for petroleum and petroleum by-products in various parts of the county both on-shore and off-shore. Due to the scarcity of natural water, there is no hydro-electric potential within the county and no prospects for such. SDG&E is currently exploring the potential for geothermal fluids as an energy source. However, the geothermal wells which we are attempting to develop are located in Imperial County. The potential energy in tidal wave action has been harnessed for electric generation in very few cases in other parts of the world where the particular topography lends itself to the economic use of this energy as it does not in San Diego County. SDG&E is currently researching various methods of harnessing solar energy. However, we do not consider this form of energy to be a practical, large scale energy source in the immediate future. We are aware of a few windmill installations within our service area which provide at least part of the users' energy requirements. Here again, we do not feel wind power is a practical source of energy in the county.

SDG&E is cooperating with a petroleum company which plans to build an oil refinery in the Carlsbad area. The developing company, Pacific Resources In ., also plans to produce synthetic gas as a by-product of the refinery operation. Some or all of this gas would be purchased by SDG&E for distribution to its customers in San Diego County. The crude oil source of the refinery products, however, would be from outside the continental United States.

In summary, San Diego County is blessed in many ways. However, it is not blessed with a practical source of energy of the type needed to supply electric and gas service."

The following fact sheets give you some basic information on the different energy sources.

ENERGY SOURCE FACT SHEET

COAL

Source

Underground, throughout the world (See World Book Encyclopedia Yearbook, 1974).

Collection

Underground and open pit mining

Transportation

Railroad, truck, barge, freighter

Storage

Stockpiles of mined coal

Use

Fuel to create heat for home and industry and to create electric power. A lot of coal is also used in making steel.

Consequences

Health hazards in mining coal; strip mining destroys surface environments; pollution from ashes, sulfur dioxide carbon dioxide, and carbon monoxide. New methods of mining coal, such as by gasification, are too expensive to use at the present time.

Availability

At the present rate of use, America's coal will last 650 years. The supply has not been used extensively in recent times due to the availability of petroleum products and the environmental concerns of mining and air pollution.

What is Coal?

Coal is a fossil fuel formed from dead plants and animals whose organic material is converted to coal by heat and pressure. It takes about 25 million years for coal to be formed.

Coal is burned to release its stored chemical energy. At present, coal provides about 20% of the United States' total energy use. Of the fossil fuels, America has more coal than oil or natural gas.

However, burning of coal can have harmful environmental effects. Coal often contains sulfur which creates a health hazard by becoming sulfur dioxide when the coal is burned. This burning also produces ashes and carbon dioxide. Some people fear that increased amounts of this gas in the air may change the weather. Present pollution control methods are very expensive. Furthermore, underground mining of coal is hazardous for miners. When the ground is stripped (like peeling an orange) to get the coal (strip mining), the earth is badly damaged. The environmental problems include what to do with the unsightly appearance, acids formed by water and leftover sulphur, ruined streams and groundwater sources, and hills of leftover dirt.

All of these environmental problems will have to be solved if coal is to be used as a major energy source. Coal is no longer used in California because of transportation and environmental considerations. However, several utility companies are currently studying its possible future use.

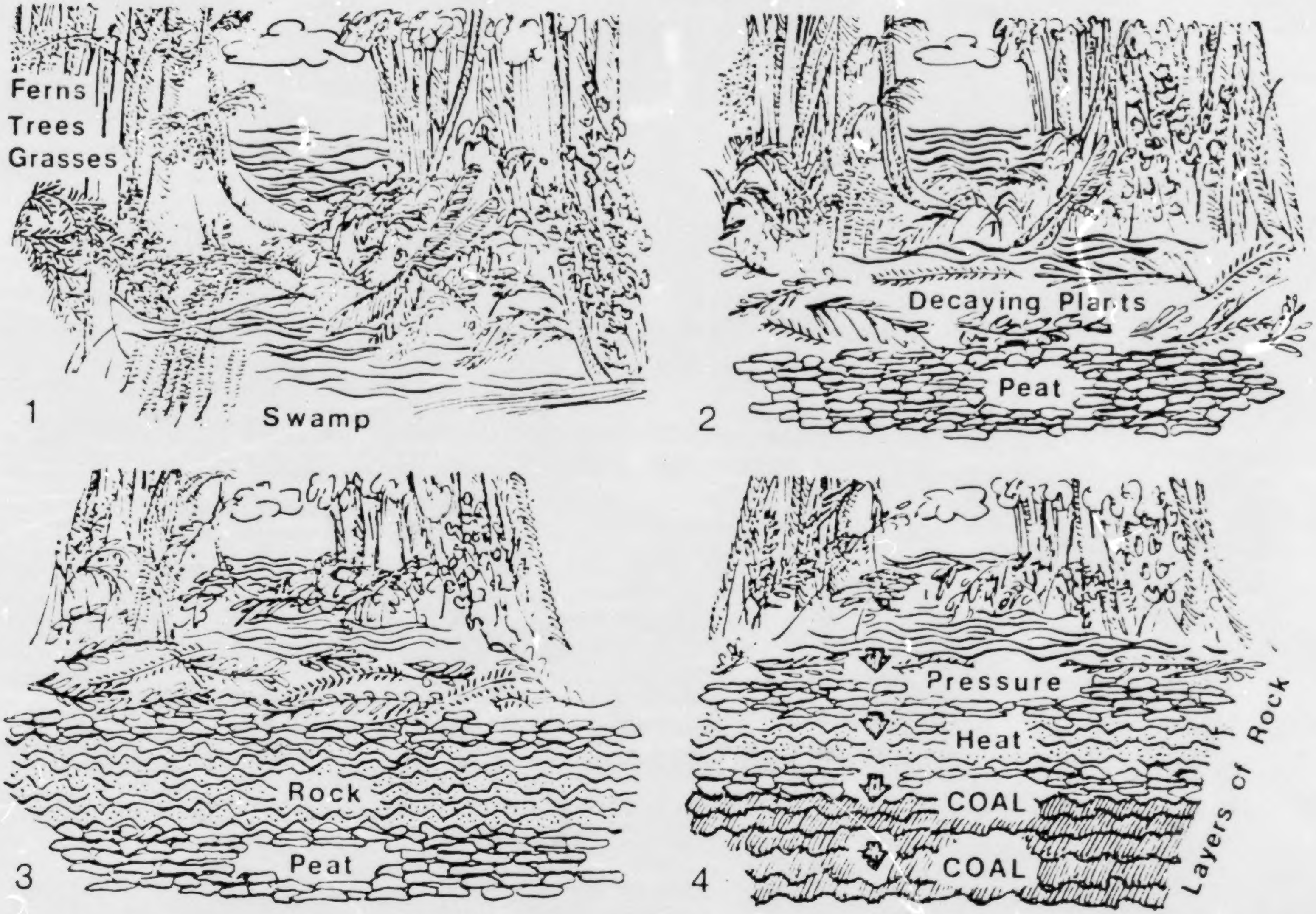
New Ideas

Some scientists think coal gasification will help solve the environmental problems. They want to set an underground coal seam on fire, then collect the gases which result. This method would get the energy value of coal without disturbing the surface environment or subjecting workers to underground mining hazards. Technology for this method needs improvement, however, and costs are high.

Cost

As of 1974, it would cost about$218 per year to heat a California home directly with coal if its use were permitted. This cost will go up as other fuels become scarce and the mining costs (labor, machinery, environmentsl, and health) increase.

HOW COAL WAS FORMED


Ferns
Trees
Grasses
1
Swamp
Decaying Plants
Peat
2
Rock
Peat
3
Pressure
Heat
COAL
COAL
Layers of Rock
4

ENERGY SOURCE FACT SHEET

CONSERVATION

Source

Available from all other sources of energy

Collection

None

Transportation

None

Storage

None

Use

Conservation will make exhaustible energy resources last longer and cost less.

Consequences

By conserving energy--that is, using less energy or using energy more efficiently--consumers or businesses save money. Conservation saves money for all of us because saved energy used somewhere else is cheaper than producing more new energy.

Availability

Conservation energy is available immediately, and the supply will last for as long as people are willing to make the effort.

What is Conservation Energy?

Conservation can be considered as an alternative source of energy. The technology now available, combined with strong conservation effort, would produce enough energy to maintain our present standard of living in the face of dwindling energy supplies.

Money must often be spent to conserve energy for other uses. An example is insulating and updating homes and buildings. However, this expense is less than the cost of producing the extra energy used by inefficient consumers. The more efficient use of energy also means an increase in the number of jobs created for each dollar of capital invested.

Conservation increases supply with the lowest risk. Many ways to conserve have been proven and the cost can be paid gradually in small steps. Once conservation improvements are made, there is no danger of this energy supply being cut off by foreign governments or changes in federal rules. Also, conservation is not likely to have a negative impact on the environment in the future.

Improved efficiency in energy use is the first step towards a basically different view of energy and the earth's physical resources. For this change each human being must recognize the limited nature of conventional energy resources. Moreover, each person must consider the serious environmental effects of the way we now obtain and use energy. In the long run, energy conservation efforts can show us how to balance our production and daily use of energy with the earth's ability to absorb wastes.

ENERGY SOURCE FACT SHEET

GEOTHERMAL ENERGY

Source

Earth heat in steam, hot water, and hot rock generally found where large amounts of molten rock lie near the surface ground. This heats deep underground bodies of water trapped in rock.

Collection

Steam or hot water rising to the surface

Transportation

Via pipes to (on site or adjacent) power plants

Storage

None after steam or hot water has been released

Use

Steam or hot water provides power to generate electricity

Consequences

Problems with disposal of waste water; high concentrations of minerals in water corrode turbines and pipes; foul smelling gases may be released into the air. Some experts worry that withdrawal of fluids may start underground earth movements. Onsite power conversion and return of water underground would eliminate some of these problems. If great amounts of heat are withdrawn from the interior of the earth, are there unknown thermal consequences?

Availability

Limited to those parts of the United States (mostly the western states) where geysers are found. The location of geothermal fields limits use of this energy source mostly to small cities in the western states.

What Is Geothermal Energy?

It is earth heat that might be able to provide much of the earth's energy. When underground heat meets underground water, hot water or steam is produced. Then steam may come up naturally as a geyser (Old Faithful) or a hot spring (Warner Hot Springs). See diagram on next page. There are several projected areas of development in California. At present, there are no geothermal wells being considered for power production in San Diego County. See diagram on next page.

By tapping 13% of the total heat from geothermal sources, we could generate enough electric power to equal 10 times our present energy output. Known geothermal sources are large and in general, easily developed. However, they are located mostly in the western states of the United States.

There are production as well as environmental problems associated with this energy source. Sometimes the water has a high level of minerals. This corrodes and clogs pipes and turbines if not removed and makes getting rid of waste waters difficult. The smelly gases, sulfur, ammonia, and boron released into the air cause pollution. There are worries that injection and withdrawals of water may trigger earth movements. The release of steam and hot water under pressure also causes noise (like a jet plane taking off) and odor. Many of these problems can be bypassed by using different methods of converting the available heat energy to electric power.

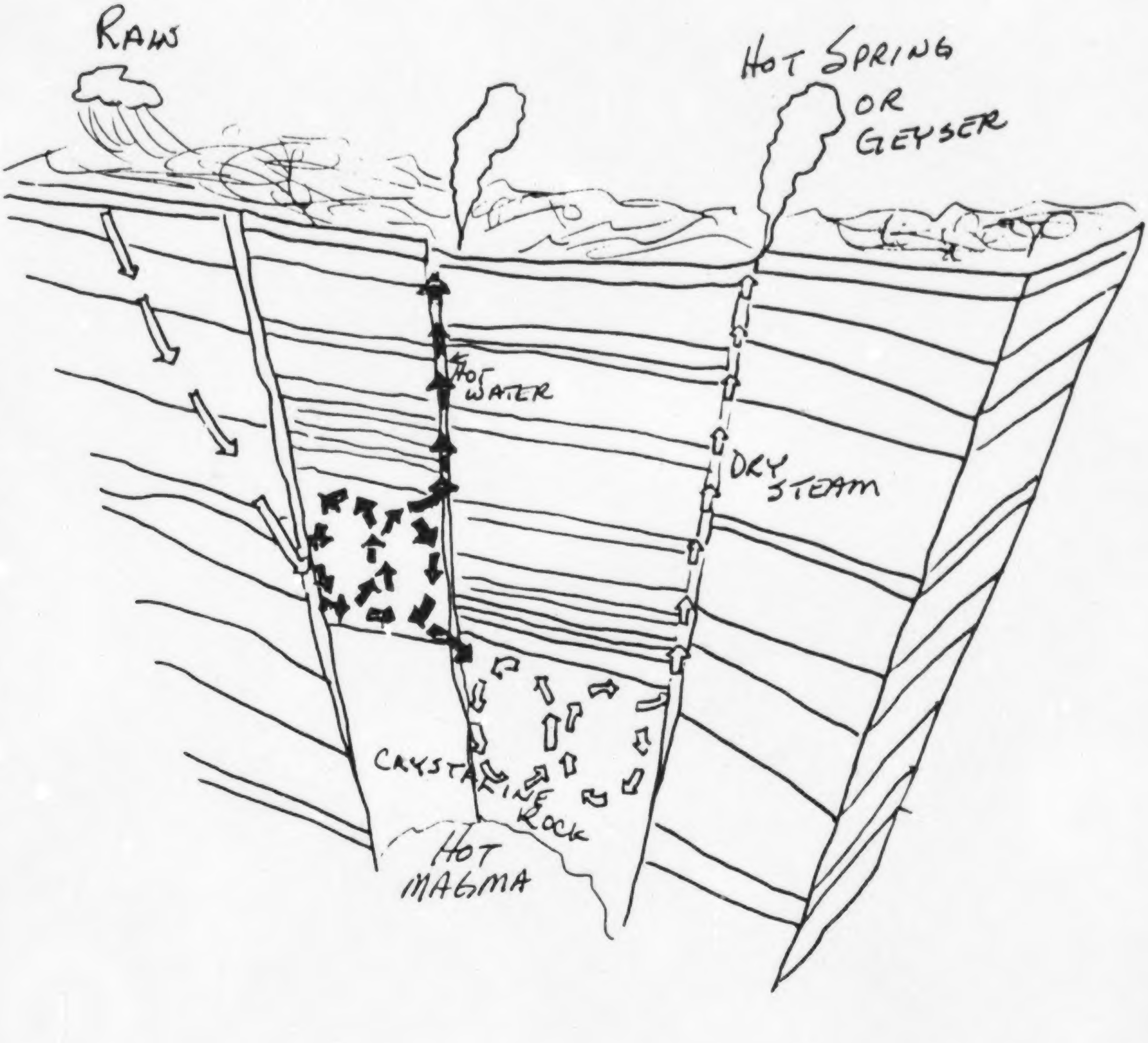
In addition, many of the good locations for geothermal power are in scenic areas such as Yellowstone National Park. Many people may not like changing those landscapes by adding electric powerplants. However, it does not affect the land the way mining does nor have the waste problems of fossil or nuclear fuels.

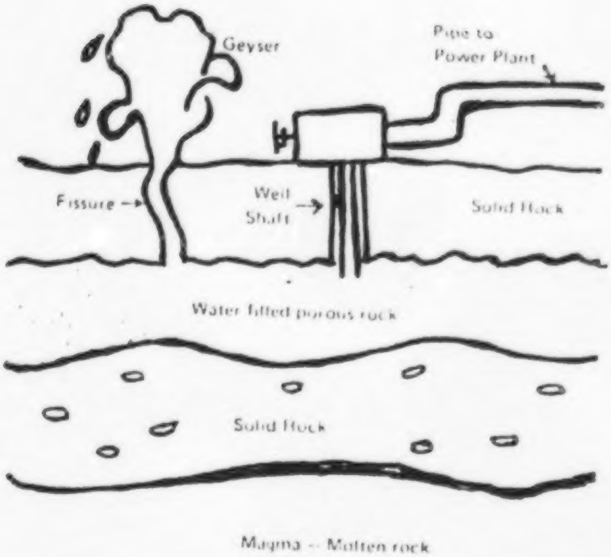
New Ideas

Some scientists are trying to find ways to circulate water through hot rocks which are not near underground water systems. If this happens, we could develop more geothermal sources.

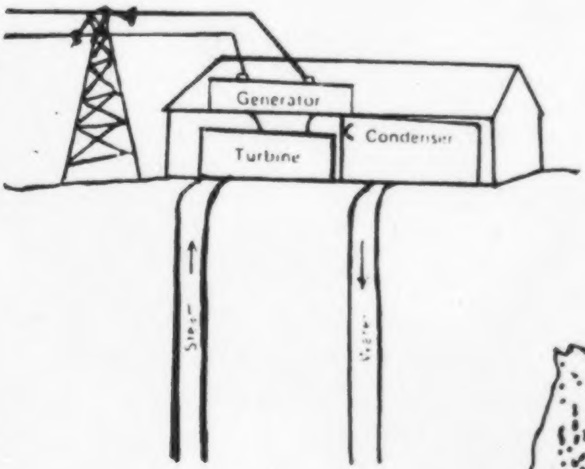
Cost

Costs are relatively low. Natural steam used to generate electricity is cheaper than oil, coal, or nuclear power. In areas of California where it is available, it would cost about $172 to heat a house (1974 rates).

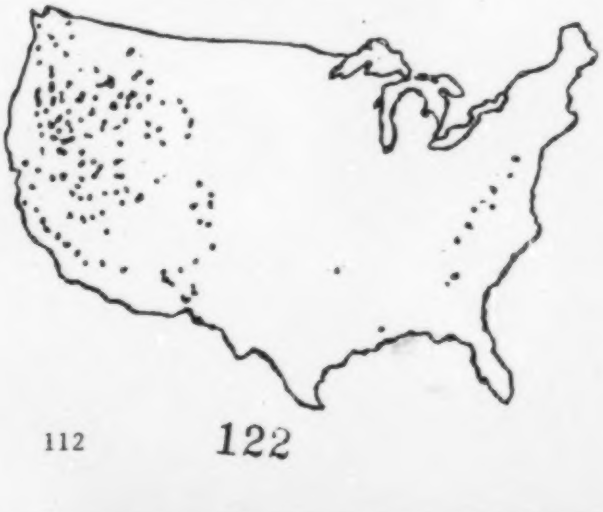

RAIN
HOT SPRING
OR
GEYSER
HOT WATER
DRY STEAM
CRYSTALLINE ROCK
HOT MAGMA


Geyser
Pipe to Power Plant
Fissure
Well Shaft
Solid Rock
Water filled porous rock
Solid Rock
Magma -- Molten rock

Today, steam rising from the earth is used to turn a turbine to generate electricity. See diagram below.


Generator
Condenser
Turbine
Steam
Water

Map of Geothermal Regions



ENERGY SOURCE FACT SHEET

HYDROPOWER

Source

Streams, rivers, rain, snowmelt

Collection

Dams, natural waterfalls, lakes, streams, rivers

Transportation

Canals, flumes, chutes, aqueducts, pipelines, rivers

Storage

Reservoirs, pump storage

Use

To generate electric power

Consequences

Sediment filling up lake; loss of valuable farm land; destruction of animal habitats; high cost of constructing dams; limited life span of dams; hazards to life and property if it breaks.

Availability

For the sole purpose of creating electricity with no consideration to agriculture, river ecosystems and aesthetics, it would require damming all major rivers to produce one half of the world's present power expenditure. Few new dam sites are available.

What is Hydroelectric?

Hydroelectric energy accounts for a small portion of electrical energy needs (about 4%). Hydroelectric energy is a clean source of power, but there are many environmental and social consequences. Damming buries large amounts of the best agricultural lands at a time when we cannot afford to lose them. In many cases, the lake behind a hydroelectric power dam starts filling with sediment and slowly renders it useless. In addition, it reduces the natural flow of sediment to the oceans, thus reducing the amount of sand for beaches.

Cost

The cost of hydroelectric power generation is also significant. Some experts estimate a life expectancy of as little as 10 years for a dam, due to sediment filling in the lake. Others estimate as much as 1,000 years of "life" for a typical dam. There is also an effect on wildlife because the sediment chokes out fish mating and spawning beds and destroys water vegetation. Probably the most important roadblock in the development of this source of energy is the lack of natural sites in the United States. Also, the high cost of building a dam limits the use of hydroelectric power in the future.

NATURAL GAS

Source

Underground gas wells or deposits; also made from coal or oil

Collection

Drilling for crude oil, drilling for natural gas deposits, collecting methane gas from organic wastes such as garbage

Transportation

Pipelines, gas tankers (trucks, railroad, ships)

Storage

Above ground in storage tanks as gas or liquid; underground wells

Use

Fuel to create heat for homes and industry; also used as a fuel to generate electricity

Consequences

As a fuel, natural gas is comparatively clean and inexpensive. (Prices are controlled by the government.) When natural gas is burned to make electric power, the nitrogen oxide given off, produced from the high temperature of burning, becomes part of smog.

Availability

In 1976, the known natural gas resources were expected to last only 10 to 15 years at that current rate of use. Estimates in 1978, based on new discoveries, suggest that supplies may be expected to last from 60 to 200 years at current world production rates. Check recent news reports for new developments in this rapidly changing situation.

What Is Natural Gas?

Natural gas is a fossil fuel mixture of gaseous hydrocarbons, mostly methane. Today, natural gas supplies one-third of the total energy used in the United States.

There is the possibility of importing liquefied natural gas from foreign sources. However, this would mean building expensive tankers and would increase the price of gas. Gasifying coal (changing coal into gas) could produce a lot of gas, but the cost of this is very high. Scientists are now trying to get usable methane gas from organic trash and garbage.

Environmental Problems

Gas is amost sulfur free and clean when burned. Gas has the least environmental impact of any fossil fuel. Natural gas used in large power plants, however, causes some environmental problems. In the high temperature produced for power generation, large quantities of nitrogen oxides (which help make smog) are produced. Also, carbon dioxide is given off into the air when any fossil fuel (oil, coal, or gas) is burned. Some scientists predict the worldwide increase in carbon dioxide may increase the earth's temperature. Fire, flameless booms, and vapor clouds are risks which may occur in handling liquefied natural gas.

Cost

Because the United States government has in the past controlled the price of gas, its cost is low. Many people say that low cost kept oil companies from trying to find new sources. In 1972, the cost of heating in a California home with natural gas was about $120. As government price controls are lifted, it is probable that gas prices will increase in the near future.

ENERGY SOURCE FACT SHEET

NUCLEAR FISSION

Source

Unanium 235, thorium, and plutonium in controlled nuclear reactions

Collection

Uranium and thorium are mined from the ground, then processed and enriched. Plutonium is produced as a byproduct in nuclear reactors.

Transportation

Fission fuels are carried in large casks made of lead and steel. These casks can survive through any foreseeable accident. They may be carried by rail or truck. The quantities of fuels needing transport are small due to the high energy content.

Storage

Fissionable materials may be stored for long periods of time in shielded locations.

Use

Nuclear fission makes heat which is used to boil water, making steam to run turbines which turn generators to make electricity. Other uses are desalting seawater, making hydrogen, coal gasification, and as a powerplant for ships and spacecraft.

Consequences

Much of the waste fuel must be kept away from living things for up to 250,000 years, (depending on the treatment of waste before storage, estimates of the time vary from six hundred years to several hundred thousand years). A nuclear reactor accident, such as the reactor core overheating, could cause the core to melt. It is considered possible that the water intended to cool the core might change to steam causing the protective shell to break and spread radioactive material over a wide area.

Availability

Sixty nuclear powerplants provide over 8% of our total electric power today. Estimates are about 35-40% of our electricity will come from nuclear fission plants in 1990. Uranium resources at these increasing rates of use will last about 30 years. If breeder reactors--they make (breed) another fuel (plutonium) as they use uranium and thorium--are built the supply may last 1500 years or more.

What is Nuclear Fission?

In fission, Uranium 235 atoms or other similar atoms are split into two or more fragments to release energy as heat.

There are two types of fission powerplants. One is called a Light Water Reactor. It uses water to heat other water to make steam to turn the generators. This requires a lot of cooling water. The second is a High Temperature Gas Reactor. This uses helium heated by the reactor which in turn heats the steam to turn the generators. One model uses helium itself to turn the generators. Of the two reactors, the High Temperature Gas Reactor is more efficient, producing more energy from a given amount of fuel.

Nuclear fission could be the way to provide lots of energy, save present energy sources (oil and natural gas), reduce fossil fuel air pollution, and produce other energy (hydrogen and coal gasification). This would help bridge the gap between the fossil fuel age and fusion power.

Even though nuclear energy may be an economical way to generate electricity, nuclear power reactors produce hazardous liquid and solid wastes. Much of this waste must be stored without any contact with the environment for up to 250,000 years.

Another danger is the possibility of a major accident such as a reactor core overheating. This could result in a hazardous leakage of radiation into the environment. Some experts say the chance of this is really quite small, perhaps as little as one in a billion.

Finally, there is the problem of security in the transport and storage of radioactive material.

Most of the problems mentioned above might (and likely will), be solved with good management and better technology, and probably will be solved. The question is whether it is worth the risk today and for future generations.

Cost

The cost of nuclear electric power is about the same as the cost of power from fossil fuels. Heating a home in California would cost about $510 per year.

SOURCES IN SAN DIEGO COUNTY

In San Diego County, the San Onofre nuclear generating station south of San Clemente is a functioning nuclear power plant. This 450 megawatt unit has been in operation since 1968. At present, two additional units are under construction at the San Onofre site, each of which will produce 1,180 megawatts. To produce the output of these two units in a fossil-fueled plant, it would require the burning of an estimated 25 to 30 million barrels of oil a year. Commercial operation of these two plants is planned for 1981 and 1982.

ENERGY SOURCE FACT SHEET

NUCLEAR FUSION

Source

Hydrogen isotopes in a controlled thermonuclear reaction

Collection

The hydrogen isotopes are separated from common water, (or sea water).

Transportation

The fuel for the fusion reaction would probably be moved in tanks as a compressed gas. It would be used in fusion reactors to generate electricity.

Storage

Electrical power can be stored in pumped water storage, hydrogen (and later run through a fuel cell), or in a large battery bank.

Use

Generation of electricity; separation of hydrogen from water; changing radioactive wastes into harmless substances; desalting seawater.

Consequences

If fusion can be developed, there is enough fuel on earth to produce hundreds of times as much power as used today for millions of years. This power would be generated almost pollution free.

Availability

Is still in the research stages. General Atomic anticipates the first demonstration power reactor to be operating in the 1990's. Operating powerplants will not be providing much of the United States' energy needs in the first decade of the 21st century. Nuclear fusion is not a solution to energy needs of the immediate future.

What is Nuclear Fusion?

In a fusion reaction, light atoms (such as hydrogen isotopes) are forced together under great pressure. During this change, large amounts of energy are released.

The U.S. Department of Energy (DOE) believes the first small-scale experimental fusion reactor will be working by the late 1980's, and a scaled-up demonstration fusion reactor by the late 1990's.

ORGANIC WASTE AND REFUSE

Source

Urban and agricultural wastes

Collection

Garbage collection, sewage, industrial refuse

Transportation

Trucks, sewer systems

Storage

Dumps, sewer treatment plants, municipal garbage incinerators

Use

Decomposition produces methane gas (like natural gas) which could be used as a fuel for heat. Flammable wastes can also be used as a fuel.

Consequences

Cost of building municipal methane plants and family-size converters would be offset by the production of a usable fuel. Methane gas would help to replace dwindling supplies of natural gas. Burning waste produces smoke and fumes which must be controlled to prevent air pollution.

Availability

The energy potential from waste could be expected to provide up to 3% of the total United States' energy needs, or up to 10% of our electrical needs.

What Is Organic Waste and Refuse Energy?

It comes from converting city and farm organic wastes to methane gas and would reduce the huge mass of refuse in this country by half or more. As a bonus, these new supplies of methane would serve to conserve or replace the dwindling fossil deposits of natural gas (primarily methane gas).

Consider these statistics: About 1.5 billion tons of city and farm waste are produced each year. This waste will increase as the population grows. Each pound of organic waste will produce about ten cubic feet (.29 m^3 of methane gas. If all this waste were processed for methane gas (probably an impossible task), we could have about 30 trillion cubic feet (857 billion m^3) of methane each year. This is about half again as much natural gas as the United States uses at this time. However, if conservation efforts to reduce waste are successful, less waste will be available as a source of energy.

Every city sanitation facility in the country could include a methane converter facility. Also possible, would be a family-size garbage converter attached to the house that could provide much of the fuel needed for cooking and heating. Production of methane gas from organic wastes and refuse could contribute to solving tomorrow's energy and waste-disposal problems.

Cost

To convert refuse to fuel is more expensive than present waste disposal techniques and exploration for offshore natural gas. But its potential makes it a logical choice as an alternative energy source.

ENERGY SOURCE FACT SHEET

PETROLEUM (OIL)

Source

Underground deposits throughout the world (under the sea floor in some locations)

Collection

Oil drilling

Transportation

Pipelines, oil tankers (truck, railroad, seagoing tankers)

Storage

Above-ground and underground storage tanks

Use

Fuel for producing heat which can be used to generate electricity or to produce mechanical energy; fuel for transportation and heating; raw material for petroleum based products and chemicals (plastics).

Consequences

Limited supply, high cost and supply uncertainties of imported oil; environmental impact and cost of drilling for new sources (e.g., offshore drilling); risks in transporting crude oil via pipeline or tanker (Alaskan pipeline); air pollution problems. Seventy-five percent of the present United States energy requirements are supplied by oil and natural gas.

Availability

Estimates vary, depending on role of use and how much is imported from other countries. At best, relying only on maximum United States resources, we have enough oil to only 35-40 years, or until the year 2015.

What is Petroleum?

Petroleum is fossil fuel made by millions of years of heat and pressure of the earth on organic materials. Petroleum is burned to release its energy.

If petroleum is used at expected rates, experts believe that by the year 2000, 90% of the world's oil may be exhausted. The current American use of oil requires increasing imports from Latin America and the Middle East. This is in addition to the use of the Alaskan pipeline to tap the North Slope oil reserves.

Importing oil has several effects on America. American dollars go out of the country and into oil-producing countries. Increased oil importation requires construction of oil supertankers with offshore ocean terminals. To ease the problems of oil importation, the United States is developing its own oil supplies, including offshore drilling.

However, the use of oil has severe environmental effects. The U.S. Office of Science and Technology reports that motor vehicles account for 44% of the country's air pollutants. Stationary fuel combusion of oil (powerplants and industry accounts for 16%. According to this report, vehicles give off 65% of the carbon monoxide, 46% of the hydrocarbons, and 37% of the nitrogen oxides. In addition to emissions, one must consider the possible environmental cost of more oil spills and petroleum-related pollution of the ocean, lakes and streams.

The environmental impact of oil utilization can be reduced through techniques such as hydrogenation to yield sulfur-free fuel. Exhaust emission control systems somewhat reduce the harmful effects of automobile emissions, but the cost and increased fuel consumption caused by these devices is considerable.

Oil shale (a limestone-like rock that is heated to release it oil) could also be used to increase petroleum supplies. Of course, getting oil shale presents all the usual mining problems plus the negative effect on the land at and near the mine sites. Large quantities of water are used in this process. The limited supply of water available in the areas where oil shale is found has restricted the use of this resource. Some experts estimate that energy expended to extract oil from shale may well equal if not exceed the energy the shale will provide.

Cost

As of 1974, heating an average home in California using only oil would cost $210.

SEA POWER (TIDAL, SEA THERMAL, AND WAVES)

Source

Oceans, currents, tides, and waves

Collection

Turbines run by incoming and outgoing tides or ocean currents; generating plants 200 feet (61m) beneath the surface of the sea (thermal); storing water in tanks above sea level; or using floats to operate booms which turn a generator.

Transportation

Varies depending on the form of collection

Storage

Hydrogen gas in tanks for electrical storage, batteries, and water in tanks above sea level for waves.

Use

Generate electricity, or in the case of sea thermal, hydrogen to produce heat or electricity

Consequences

Restrictions on recreation and fishing near these plants and cluttered beach areas

Availability

There are few places in the world where there is enough variation in tides to generate electricity efficiently. Limited number of sites for sea thermal, changes in wave power, and the number of waves limit the places where this power is feasible. Major ocean currents are often not close to land.

What is Sea Power?

Tidal sea power is possible along a coast where there is a high rise in tide. At high tide water flows through turbines into a bay, and during low tide, it flows back out. Conversion to energy is possible only during tidal flow, about 3-1/4 hours each way twice a day along the Pacific coast. Thus energy is generated for only 13 out of 24 hours. There are only a few places in the whole world where this is practical.

Sea thermal power is possible because of the difference between surface, warm sea temperature, and cold, deep water temperature. A gas (like freon used in refrigerators) at sea level would turn a generator, then be pumped deep to be cooled into a liquid, and then be brought to the surface to expand into a gas and turn the turbine. The electricity generated would be transported to shore through cables.

Waves could generate electricity by forcing water through valves in pipes into a tank above sea level. This water would run a turbine on its way back to sea. Or, floats could be mounted along the shoreline, connected with the shore by a long boom. The up-and-down motion of each boom would turn a generator.

Cost

Costs for these ideas are fairly high, too high in comparison to present alternatives. Also, the efficiency factor is low, with the possible exception of the sea thermal alternative. Costs are roughly twice as much as conventional power plants.

FACT SHEET

SOLAR ENERGY

Source: Sunlight

Collection: Photo cells (photovoltaics): metal panels, metal or plastic piping, plastic or rubber hose containing water or air to be heated, collected through photosynthesis in plant life; "solar farms".

Transportation: Varies, depending on the form of collection.

Storage: Heated water, heated air, batteries, and stored in the form of plant tissue through photosynthesis.

Use: Can be converted directly to electricity, used to heat water which in turn can power generators to create electricity, convert to nonpolluting fuels like methane and hydrogen, food energy in plants.

In order to gather solar energy, large arrays must be built. It is estimated (IPRI) that 47 square miles of solar arrays (collectors) would be required to produce 1 billion watts of electrical energy.

The Department of Energy report "Distributed Energy Systems in California's Future" says 70 square miles of land will be required to produce 100 million watts of electrical energy.

The conversion of light rather than heat into electricity involves photovoltaic conversion whereby solar cells exposed to the sun deliver electric current. Cadmium sulfide and crystal silicon cells are expensive to produce. Based upon present technology using solar cells to generate electricity is still 100-200 times more expensive than using conventional nuclear fueled plants.

The use of solar energy to assist in space and water heating may reduce somewhat the dependence upon fossil fuels for heating.

ENERGY SOURCE FACT SHEET

WIND

Source

A daytime heating and nighttime cooling of the atmosphere which produces winds.

Collection

Windmills, sails, wind turbines

Transportation

By wire (when used to produce electricity): by pipe, truck, or ship (when used to produce hydrogen)

Storage

None directly; as hydrogen gas in tanks. Storage possibilities for mechanical and electrical energy include improved batteries, flywheels, pumped water storage (pumping water to an elevated tank, then releasing the water to drive turbines), and compressed air storage.

Use

Wind can be used as kinetic energy (as with sail boats), or converted to mechanical, electrical or chemical energy.

Consequences

Low cost, renewability, and the fact that the methods of harnessing wind power do not degrade the environment give this source of energy a good potential. However, many windmills spread across a mountain range, open plain, or valley might be unsightly. A Department of Energy official has calculated that it would take 1,500 windmills with 300 foot-long blades to generate 1 billion watts of electricity. He added,"That would be a row of windmills 870 miles long, all taller than the Coronado Bridge." Wind power requires 10,000 times more space than coal or nuclear power plants.

Availability

Wind power can be used almost immediately on both large and small scales. The technology to use this source of power is already available for small-scale use and there should be little difficulty in designing efficient large-scale systems.

What Is Wind Power?

For over 4,000 years wind has been used to produce power for pumping water, milling grain, and moving vehicles such as boats. Recently our use of wind as an energy source has declined because it was thought that there were other cheap fuels (petroleum, coal, nuclear, and hydroelectric). However, costs of fossil fuels have gone up as the supply as gone down. There are few new sites available for hydroelectric power. There are environmental worries about nuclear energy. All these have given renewed hope for wind as a significant power source.

Frank Rom of NASA thinks that half the electric power needs of the United States could be met by placing wind machines, one per square mile, throughout the Great Plains of the Midwest. Another possibility might be to place windmills on floating platforms off the Atlantic or Pacific Coasts. Of course, there are problems with unreliable wind speeds. Some of these could be overcome by moving many windmills into areas where wind is strong, steady, and predictable.

To solve the problems of unpredictability and storage of wind generated power, different systems to convert and store the power are now possible. One solution is to use wind power to electrolyze water. This will produce hydrogen gas, a flammable fuel which could then be stored and transported through pipelines as needed. Improved batteries, flywheels, pumped storage of water, and compressed storage of air are also possible answers.

The major project now is to design efficient, economical windmills to aid energy needs in both developed and developing nations. It is possible that small windmills, along with solar energy absorbers and waste recyclers, could provide total energy needs for individual homes.

Wind power is self-renewing, nonpolluting and plentiful. It shows high promise as a major source for our future energy needs.

Cost

Cost for wind generated power on a small scale (individual homes or farms) is about the same or a little more than current electrical costs. Large-scale operations are presently more expensive; low mass production techniques and higher fuel costs will soon make them equal.